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FAMILIAR BRITISH WILD FLOWERS AND THEIR ALLIES.

By R. LLOYD PRAEGER, B.A.

V.—HEATHS AND GENTIANS.

HEATHS and Gentians! What pleasant pictures do the names bring before the mind. Beautiful plants, with graceful forms and brilliant flowers. Summer days amid the hot bee-filled heather. Wide brown moors, or alpine flower-starred pastures. In point of fact, the plants constituting these groups are, like the Saxifrages, redolent of the wild open country; of rock, and sand-dune, and mountain solitude. The fertile plains yield but a scant few of them; about the murky town we seek in vain a single one. And at this season of the year, when many of us are away in the home of the Heaths and Gentians, or have still fresh memories of the mountain breeze, and the fragrance of the Heather, we may appropriately spend a little while in a study of plants which give us so much pleasure.

The Heath family, or *Ericaceæ*, forms an assemblage of shrubs—or occasionally herbs—which have a wide distribution over the globe. They are generally found in rocky or boggy places in temperate countries, and especially frequent sub-alpine regions. The Cape of Good Hope is the home of an immense number of species of the typical and largest genus of the Order *Erica*. This genus yields the numerous lovely Heaths that are found in cultivation, and which must be ranked among the most beautiful plants which our greenhouses can boast. The plants of this Order have, as their most remarkable character, their beauty. Only a few possess medicinal or other properties. In the whole vast genus *Erica* there is not a single instance of a medicinal species. A few members of allied genera, including the familiar Ling (*Calluna vulgaris*), and the Bearberry (*Arctostaphylos Uva-ursi*), are astringent. Some of the Rhododendrons and Azaleas are strongly narcotic. The berries of some succulent-fruited species, such as the Cranberry, are used as food, but the list of economic virtues in the Order is very short. But from the point of view of aesthetics, what a gold mine the *Ericaceæ* furnish. Not only the myriad many-tinted Heaths, but the glorious Rhododendrons and Azaleas belong here; also the Kalmias, Andromedas, Ledums, and Arbutus. The species, as a whole, show a decided preference for peaty soils, and many of them cannot endure lime, which renders difficult the cultivation of the larger sorts, such as Rhododendrons, in certain districts.

Leaving the gorgeous Himalayan Rhododendrons and Cape Heaths, we must turn to the British representatives of the Order, which, if modest in comparison with these glorious plants, are nevertheless full of beauty and interest. The British *Ericaceæ*, taking the term in a wide sense, may be divided into five tribes: *Arbuteæ*, characterized by a succulent superior fruit, and represented by the Strawberry-tree and Bearberry; *Ericeæ*, including the Heaths and their immediate allies, all small shrubs; *Vaccinieæ*, with a fleshy inferior fruit, represented by the Whortleberry and its relations; *Pyroleæ*, containing the beautiful Wintergreen; and *Monotropeæ*, consisting of strange white or brown leafless herbs, of parasitic or saprophytic habits.

The Strawberry-tree, *Arbutus Unedo*, is the largest of the British *Ericaceæ*, forming a small bushy tree which may attain a height of twenty feet. Its evergreen foliage, clusters of winter-borne Lily-of-the-Valley-like flowers, and pretty, rough, scarlet fruit, make it a favourite in shrubberies. As a native, it grows only in a small portion of the south-west of Ireland. Around the shores and on the islands of the Upper Lake of Killarney it may be seen at its best, contributing very materially to the arboreal vegetation of that delightful spot. Abroad, it occurs across the Spanish peninsula, and all along the Mediterranean. The Bearberries (*Arctostaphylos*) are small evergreen shrubs, with pretty *Arbutus*-like flowers and shining berries. *A. alpina*, which has bluish-black berries, is a rare Scottish alpine. *A. Uva-ursi* is more widely spread, and though generally alpine in its distribution, in the west of Ireland it descends in sheets to sea-level. It has far-stretching, trailing, branching stems, pink flowers, and bright red berries.

We come now to the *Ericeæ*, or true Heaths. Of the six British Genera—*Andromeda*, *Calluna*, *Erica*, *Azalea* (= *Loiseleuria*), *Phyllodoce* (= *Bryanthus*), and *Dabeocia* (= *Borelta*), all but the third (*Erica*) have only a single representative. All are small evergreen shrubs, affecting peaty soils. The Marsh Andromeda (*A. Polifolia*) is a plant of peat bogs, with the leathery recurved leaves, dark green above and white beneath, which so many of the Heath allies possess, and pink urn-shaped blossoms, which

are produced in early spring. The Ling (*Calluna vulgaris*) is familiar to every one. It is the most abundant social plant in the British flora. Over mile upon mile of mountain and moor it dominates the vegetation, and is equally

FIG. 1.—The Strawberry-Tree on a Kerry lake-shore.
[R. WELCH, Photo.

at home on southern sand-dunes and on Scottish mountain-tops. Examine the flower carefully. The calyx is conspicuous and coloured, deeply cleft into four lobes; the corolla quite insignificant in comparison, bell-shaped, and much shorter than the calyx. Note also the tiny leaves, arranged in four close rows. The genus *Calluna* possesses only this one species; but it makes up in number of individuals what it lacks in variety. The Ling is spread all round the Northern Hemisphere, and where it occurs it usually forms a conspicuous feature of the vegetation.

The Heaths proper (*Erica*) number six British species. Two of these, the common purple Heather (*E. cinerea*) and the pink Bell-Heather (*E. Tetralix*) are familiar plants on every heath and mountain side. The other four are of very local and peculiar distribution. Two of them, the Mediterranean Heath (*E. mediterranea*) and Mackay's Heath (*E. Mackaii*) are confined to a definite area in the west of Ireland, in the counties of Galway and Mayo. The other two, the Cornish Heath (*E. vagans*) and the Fringed Heath (*E. ciliaris*), grow only in a restricted area in the south-west of England, in Cornwall and Dorset. All four are elsewhere found only in western France and the Spanish peninsula. This group of four Heaths forms, indeed, the focus of that peculiar group of plants of the western edge of Europe—West Ireland, West England, and the Pyrenean region—whose remarkable range has given rise to so much speculation among naturalists, and to the postulating of a former extension and continuity of the edge of the Continent, which formed a land surface along which these and other plants—and many animals likewise—migrated freely on the old edge of the Atlantic (*see* KNOWLEDGE, December, 1901, pp. 284-5). Of the four rare Heaths mentioned, *E. Mackaii* is a small plant with a habit like *E. Tetralix*. *E. ciliaris* is a taller handsome plant with bright flowers in unilateral racemes. *E. vagans* grows several feet high, forming compact bushes with stiff erect branches. The small flowers are borne in racemes near the ends of the branches. *E. mediterranea* is the largest British Heath, forming bushes which may attain five feet in height, with erect branches clothed with spreading leaves. The pink blossoms appear in early spring, and the plant is usually at its best by March. The remaining three genera, *Azalea*, *Phyllodoce*, and *Dabeocia*, each with a single species, are rare plants of restricted distribution. *Azalea procombens* is the most frequent of the three—a tiny tufted shrub found on the summits of high Scottish mountains, with crowded dark green leaves and umbel-like clusters of pretty pink flowers. *Phyllodoce cærulea* is also alpine in habitat, growing only on the Sow of Athol in Perthshire. It is a low-creeping shrub, with crowded narrow leaves and large single egg-shaped purplish flowers. Lastly we have *Dabeocia polifolia*, the largest-

FIG. 2.—St. Dabeoc's Heath. Half natural size.

flowered of all the British Heaths, growing only in Galway and Mayo, and forming another of the peculiar Irish-Pyrenean plant-group which has been already referred to. It is a trailing shrub, with ovate leaves conspicuously white beneath. The stems end in racemes bearing beautiful drooping egg-shaped bells half an inch in length. Its abundance amid the bogs and mountains of Connemara is to the botanist one of the most striking features of that wild and fascinating country.

Before passing away from the Heaths and their allies, a word is desirable as to certain features of leaf and flower which they display. In the flowers, the stamens strike us at once as peculiar. Take the flower of the Bell-Heather (*E. Tetralix*) for example (Fig. 3). The pendulous egg-shaped blossom has a comparatively small opening. The

style, occupying the axis of the bell, terminates in a stigma lying right in the opening. Surrounding this, and a little shorter than the style, are the stamens. The anthers are

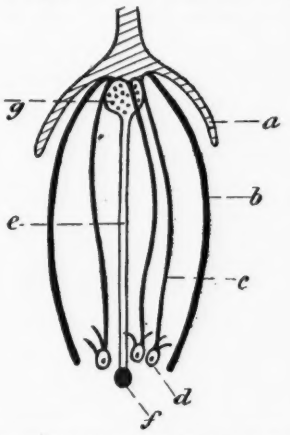

FIG. 3.—Diagrammatic Section of Flower of *Erica Tetralix*. *a*, Calyx; *b*, corolla; *c*, filament; *d*, anther; *e*, style; *f*, stigma; *g*, ovary. Enlarged.

roundish, and instead of splitting open, open by a pore at what, in the inverted position of the flower, is the lower end. Attached to each anther are two curious spreading horns. The stigma and the horned anthers almost block the entrance of the flower. Honey is secreted at the further end, near the ovary. The flowers are visited chiefly by bumble-bees. The bee, alighting on the bell, pushes its forehead against the stigma. At the same time its proboscis, pushed into the flower in search of honey, comes in contact with the spreading appendages of the anthers, and the disturbance causes pollen to drop out through the pore on the bee's forehead. Thus cross-fertilisation is effected. As to the leaves. That the leaves of many of these plants are curled backwards is a matter of common observation, but it is only on careful examination that we find how far this is carried in some of the species. While in the little Azalea (Fig. 4, 1) the leaf

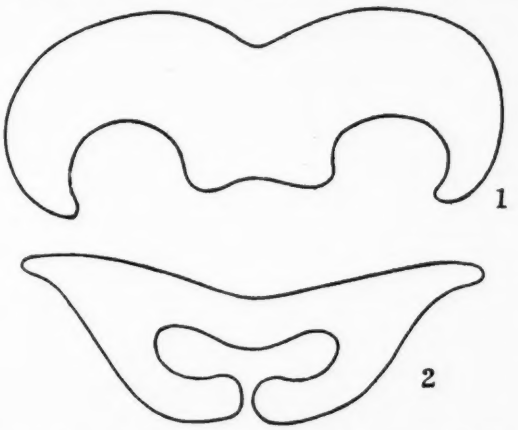

FIG. 4.—Outline sections of rolled leaves of *Ericaceæ*. 1, *Azalea*; 2, *Andromeda*. Enlarged.

is merely curved backwards, in others the curling is carried so far that a chamber is formed, the edges of the leaf almost meeting behind. The lower drawing on Fig. 4, which represents a foreign species of *Andromeda*, exemplifies this peculiarity. Similar chambered leaves are found in many plants—notably in grasses—and the object they serve is to prevent too rapid transpiration; the stomata, which are situated on the back of the leaves, being thus enclosed in a cool moist chamber. It may naturally excite surprise that the Heaths, which are in so large measure bog plants, growing in a soil reeking with water, should be thus protected from loss of water. The answer to this puzzle lies in a peculiar property of boggy soil, to which I have made reference in a previous article (KNOWLEDGE, September, 1902, p. 210). The water-logged soil is so badly aerated that soluble humus compounds remain in solution. Plants find difficulty in absorbing water charged with these substances, and hence they take precautions against undue waste of water. Such precautions we see in the small size of the leaves of the Heaths, and their rolled character.

To proceed with our review of the native *Ericaceæ*. The British *Vaccinieæ* comprise only the genus *Vaccinium*, which has four species. The familiar Whortleberry or Bilberry (*V. Myrtillus*) needs no description. Note the pretty pink urn-shaped flowers, produced almost before the leaves, and the curious spurs on the anthers—very characteristic of the Heath family. *V. uliginosum*, the Great Bilberry or Bog Whortleberry, is a small shrub with the general appearance of the last, found on mountains in Scotland and the North of England. *V. Vitis-Idæa*, the Cowberry or Red Whortleberry, has its home amid alpine rocks. It is a small shrub with creeping stems, producing upright shoots which bear shining evergreen leaves like those of Box, and pink flowers in which the corolla is more deeply cleft than in the before-mentioned species, being bell-shaped and five-pointed. The berries are red when ripe. The last species, the Cranberry (*V. oxycoccus*), is one of the most delightful of British plants—a tiny shrub, creeping among Sphagnum or short Heather, with long thread-like shoots, and short flowering stems which bear exquisite pink blossoms with four recurved petals. The leaves are recurved, glossy green above, white below; the berries large and red in colour. Altogether it is one of the daintiest plants which has a place in our flora.

The remaining *Ericaceæ* are plants of a quite different appearance from any of the preceding. The *Pyroleæ* are represented by four species of *Pyrola* and one of *Moneses*. The Pyrolas are pretty plants with a rosette of roundish root-leaves from which springs an upright stem bearing a graceful raceme of white or pinkish waxy flowers, with incurved petals and a remarkably long style. *P. rotundifolia* is a rare plant of bushy and reedy places; its flowers have a peculiar appearance owing to the drooping style, which protrudes from among the bundle of stamens. *P. media* and *P. minor* are of more frequent occurrence, in heathy places. They have a tolerably close resemblance, but may be distinguished by their straight style, which is much longer than the stamens and crowned with a ring in *P. media*, equal to the stamens and without a ring in *P. minor*. The fourth species, *P. secunda*, is montane in habitat, and distinguished, as its name implies, by the flowers on the raceme all facing in one direction (secund). The leaves, too, are oval, pointed, and serrate; instead of more or less orbicular and slightly crenate, as in the other species. The style is long and straight, with a large stigma. *Moneses grandiflora* is a rare north-Scottish wood plant, allied to *Pyrola*, but with large single white blossoms.

Lastly we have the *Monotropeæ*, represented in our country by the single species *Monotropa Hypopitys*—or *Hypopitys Monotropa*, if one prefers that. This curious flower has none of the characters which we associate with the Heath family. It is a pale yellowish plant, devoid of

leaves, and sending up fleshy scaly stems which bear a number of drooping flowers of the same hue. The Yellow Bird's-nest (as it is called, from its resemblance to the Bird's-nest Orchis) is a rare and rather southern plant in Britain, growing in thick woods, generally under Beech or Fir trees. Its whole appearance—the absence of leaves and of green colouring matter—suggest a parasitic or saprophytic habit. If we examine its curiously tangled root-system, it will be found to be intimately associated with the mycelium, or webby underground portion, of a fungus; and the plant is always found in a soil rich in humus—in the leaf-mould that forms under thick trees. The plant feeds on the decaying vegetable matter, and apparently the process is rendered easier—or, perhaps, possible—by the presence of the fungus, whose thready stems are closely interwoven with the tissue of the root. The relations existing between the fungus and the *Monotropa*, with reference to the process of assimilation, however, have not yet been made clear.

The Gentian family is tolerably closely related to that of the Heaths, but it was association, rather than affinity, that suggested the bracketing of the two in the present sketch. Like the Heaths, this is one of those groups of plants whose presence makes one glad with the thought that towns are left far behind, and that sand-dune, moor, and mountain are around one. And while they differ from the Heaths in being all herbaceous, they rank worthily with them in attractiveness of form and colour. The two leading genera are *Gentiana* and *Erythræa*. The British Gentians have all blue or purplish flowers, the Centaurys all pink. Our native Gentians are five in number. The largest is *G. Pneumonanthe*, the so-called Calathian Violet, a plant confined to England, so far as the British Islands are concerned. Its stems are about a foot high, ending in large upright deep blue bells with five segments, each bearing a pale stripe. Next come our two commonest species, *G. Amarella* and *G. campestris*, small upright annuals, growing on dry heaths and pastures. In habit and leaf these two resemble each other, but they may be easily distinguished by the calyx, which has five equal segments in *G. Amarella*, four unequal segments in *G. campestris*. The corolla is likewise five-parted in the former, four-parted in the latter. Finally we have two small mountain species. *G. nivalis* is a tiny annual, with an upright stem and bright blue flower, found only on high mountains in Perth and Forfar. Lastly we have *G. verna*, the most beautiful of our Gentians. It is a little tufted perennial, which in spring sends up a profusion of almost stemless flowers of the most wonderful vivid blue colour. It is a plant of limestone rocks, in England confined to sub-alpine situations in the north, in Ireland occupying a large area of low-lying as well as upland limestone country chiefly around Galway Bay. Though so local, it is usually abundant where it occurs; and the Galway pastures in April, all painted with its blossoms, form a sight never to be forgotten.

Fig. 5.—Flower of (1) *Gentiana Amarella*, and (2) *G. campestris*. Natural size.

The Centaurys recall, in their dwarf upright growth and opposite pairs of leaves, the annual Gentians; but their bright pink flowers render them easily recognizable among all the summer vegetation. Several forms occur, to which some botanists assign specific rank, while others treat them as sub-species of our aggregate, *E. Centaureum*. It is needless to enter into the characters of these forms in this place. Allied to *Erythræa* is *Cicendia*, of which our only species, *C. filiformis*, is a very slender and almost insignificant upright annual like a tiny Centaury with four-parted yellow flowers. It grows on damp sandy ground in the south-west of England and of Ireland. The genus *Chlora* has likewise only one British species, the well-known Perfoliate Yellow-wort, *C. perfoliata*, an annual plant easily recognized by its upright almost unbranched stems, with opposite glaucous leaves joined at their base, and bright yellow flowers. The *perfoliate* character of the leaves is worth noting, as this is one of the few British plants displaying that feature.

Fig. 6.—Perfoliate leaves of the Yellow-wort. Half natural size.

The two remaining British *Gentianaceæ* are plants differing widely from any which we have considered; a difference to be chiefly accounted for, no doubt, as in the case of *Monotropa*, by the different walk of life which they have chosen. One is a marsh plant, the other a water plant. The Bog-bean (*Menyanthes trifoliata*) grows in wet bogs and on the edges of pools. It is fleshy in all its parts. The stems, as thick as one's finger, often creep for several yards. They bear leaves with three broad egg-shaped leaflets, and racemes of remarkably pretty flowers. These are pink or white, and the inner side of the petals is densely covered with curious thick white hairs, which give the flowers a most peculiar appearance, differing from that of any other British plant. The last plant of the Gentian family is *Limnanthemum peltatum*, a thorough aquatic, living in ponds and slow rivers. This plant has adopted the floating leaves which the Water-Lilies and other plants find serviceable, and it looks very like a miniature Water-Lily, with its round leaves and yellow blossoms rising from among them. The root-stock is far below, creeping in the mud, and sends up at intervals to the surface shoots bearing the foliage and flowers. This is rather rare as a British plant—at least as a native—occurring chiefly in the midland counties of England.

MODERN COSMOGONIES.

By Agnes M. Clerke.

IV.—TIDAL FRICTION AS AN AGENT IN COSMOGONY.

The effects of tidal friction are of almost infinite complexity. How it will act in each particular case cannot be predicted off-hand; it is a matter for detailed enquiry. Mutually countervailing influences have to be taken into account; nor is the balance easy to strike. How it inclines may indeed often depend upon qualities and relations of the bodies concerned which lie outside the range of what can be distinctly ascertained. All that can be hoped for, then, is to arrive at estimates neither misleading by their ostensible precision, nor yet so vague as to be wholly uninstructive, of the part played by tidal forces in moulding the history of connected globes.

The assumption that they attract one another as if the mass of each were collected at its centre, is one of those convenient fictions without which the advancing feet of science would be impeded by entangled thickets of illusory refinements and superfluous elaborations. The fiction would correspond with fact only if the globes were truly spherical, and they could be truly spherical only if

they were ideally rigid. Cosmic bodies, however, suns and planets alike, are actually plastic spheroids; they can, to be sure, be treated without sensible error as attractive points when their distances are very great relatively to their diameters; but upon a closer approach inequality of action supervenes. The component parts of the gravitating masses respond, each individually, and in a measure independently, to the graduated pulls exercised upon them, and tidal strains begin variously to take effect.

Their historical significance was in part divined by Kant. His penetration of so recondite a secret is truly astonishing. A struggling young pedagogue in a remote Prussian province, profoundly learned, though no more than half-skilled in technical acquirements, saw by intuition what escaped the acumen of all the great geometers of the eighteenth century, namely, that the moon turns one perpetual face towards the earth, because its primitive rotation was stopped by the friction of earth-raised tides. He perceived besides that a reciprocal action of the same kind must affect the earth, and will continue to affect it until the day coincides in length with the month. Nor did he fail to point out that, in a molten state of the globes, the process would advance with comparative rapidity. To one solitary thinker, then, it became apparent, already in 1754,* that oceanic tides are, in cosmogony, of negligible importance compared with bodily tides.

There is no substance in nature that will not change its shape through prolonged stress, and the more readily the nearer it approaches to the fluid condition. The measurable heaping-up of the waters on the earth's surface at the bidding of the moon is thus a differential effect. It serves to gauge the relative mobilities of the solid globe and of its liquid envelope. If the former did not yield at all to the pull so readily obeyed by the latter, the tides would in fact be greater than they actually are in the proportion of about three to two, the ratio indicating for the earth an effective rigidity at least equal to that of steel.† If there were no discrepancy in rigidity between the various parts of our terraqueous world there would be no perceptible tides. The ocean and the bed of the ocean would rise and fall together, and to the same extent. In the far past, however, there was no discrepancy. The viscous earth took, as a whole, the form momentarily impressed upon it by the unequal attractions of the sun and moon on its variously distant sections, with the upshot of bringing the year, month, and day into relations so familiar as to appear inevitable.

But tidal friction does not merely act as a check upon rotational speed. One element of motion in a system cannot be altered without some counter-change in the others. They are coupled up together like a train of geared wheels. From the principle of the conservation of moment of momentum, we know with certainty that a loss in one direction must be compensated by a gain in some other. Tidal friction had then reactive consequences. They were first adverted to by Julius Robert Mayer in 1848,‡ and were brought prominently into view in the series of investigations begun by Professor Darwin in 1879. The rotational momentum removed from the earth by the drag of a circulating wave of deformation must assuredly have reappeared in some other part of the system. It was restored, in fact, by the widening of the lunar orbit.§ Concomitantly with the slackening of the earth's axial rate, the moon retreated from its surface pulled forward by the tidal crest continually in advance of its position. This redressed the balance by increasing orbital momentum, while at the same time diminishing the moon's linear velocity. The importance of this secondary frictional effect in the history of the earth-moon system was the virtual discovery of Professor Darwin.

That system occupies a critical situation in the solar cortège. The planets interior to it have no satellites; the planets exterior to it (Neptune making probably only an apparent exception to the rule) have two or more. The earth alone is truly binary; and the moon is not only its solitary companion, but it is by far the largest companion-body, relatively to the mass of its primary, to be found within the precincts of the solar domain. These circumstances are certainly not disconnected one from the other, and they obviously depend upon a single cause. Solar tidal friction was here the determining factor. The apportionment of satellites to the various planets was, beyond doubt, to a great extent prescribed by the degrees of retarding power over their axial movement brought to bear through the agency of sun-raised tides in their still plastic bodies. Hence the disruptive rate of spinning needed for the separation of satellites was never attained by either Mercury or Venus; they remained moonless for all time, and exposed, through the cutting down of their rotational velocity, to uncompensated extremes of temperature. How the earth was to fare in both respects, long hung in the balance. Rightly to forecast its destiny would indeed have demanded no common perspicuity in an intelligent onlooker. Although the solar drag upon its rotation had no more than one-eleventh its power over that of Venus, it nevertheless sufficed during uncounted ages to hinder acceleration from reaching the pitch involving instability. Our embryonic planet had long ceased to be nebulous, and had in fact shrunk by cooling nearly to its present dimensions before the die was cast. Then, at last, the hurrying effects of contraction prevailed over slowing down by tidal friction, axial speed overbore equilibrium, and the spheroid divided. Now globes thus far advanced in condensation are apt to split less unequally than globes in a more primitive stage; and the moon, because late-born, was of large size. Its mass is $\frac{1}{81}$ that of the earth; the masses of Titan and Saturn are as 1 to 4600; while Jupiter's third and greatest satellite contains only $\frac{1}{11300}$ part of the matter englobed in the parent-body. Moreover, Professor Darwin has made it clear that the satellites of Jupiter and Saturn revolve now in orbits not widely remote from those at first pursued by them; the moon, on the contrary, having started on its career almost, if not quite, from grazing contact with its primary. Owing to these two exceptional circumstances—its considerable relative mass, and its close initial vicinity—the moon wielded over the earth tidal influence incomparably more powerful than that exerted by any of its compeers in the sun's realm. Within its bounds, accordingly, the lunar-terrestrial system offers an unique example of a pair of globes, the mechanical relations of which have been settled on their present basis by the predominating agency of bodily tides. It holds forth, too, the one case in which origin by fission was possible. Professor Darwin's communication to the Royal Society in 1879 occasioned a remarkable diversion of ideas. Saturn's Rings were at last perceived to be illustrative of only one among many feasible modes of cosmic growth. It became clear that a single cut-and-dried method would not answer all the infinitely varied purposes of creative design. Annulation might have served its turn, but there were alternatives. A fresh stand-point was virtually attained, and the wide prospect commanded by it begins

* "Sämmtliche Werke," Bd. VI., pp. 5–12, 1839.

† G. H. Darwin, "Ency. Brit.," art. *Tides*.

‡ "Dynamik des Himmels," p. 49.

§ Darwin, *Phil. Trans.*, Vol. CLXXII., p. 528.

XUM

already to spread out invitingly before the gaze of investigators.

But whether the moon emerged from the earth as a protuberance, or was abandoned by it as an equatorial-ring, it was revolving, when our theoretical acquaintance with it begins, in a period of not less than two, and not more than four hours, quite close to the earth's surface; while the nearly isochronous rotation of the earth was conducted with all but disruptive rapidity. The situation is so suggestive that it needs only a short and tolerably safe leap in the dark to reach the conclusion that the two globes had very recently been one. With their division, at an epoch estimated to have been at least fifty-four million years ago, the process began by which the moon was pushed back along a widening spiral course to its present position, the vanished rotational momentum of the earth cropping up again in the augmented orbital momentum of the moon. And the transformation is, at least in theory, still going on.

Tidal friction has further capabilities. The transference of momentum from one part of a system to another is only the most obvious among the crowd of its results. Scarcely an element of movement escapes its influence. It increases, as a rule, orbital eccentricity. The smallest initial deviation from circularity develops, through the inequality of accelerative action thence ensuing, into pronounced ovalness. That of the moon's path can in this way be accounted for. Moreover, its plane was, in all probability, shifted simultaneously, and under compulsion of the same power, from its original coincidence with the earth's equatorial plane to the level now occupied by it. The obliquity of the ecliptic, too, is partially explicable on the same principle. "The present motion of the two bodies" (to quote Professor Darwin's words) are "completely co-ordinated by the theory that tidal friction was the ruling power in their evolution." Holding this clue, we are enabled to trace them back to the start of their dual existence, and to follow the insensible modifications by which their state was moulded to its actual form.

In no other satellite-system is this possible. No moon besides our own possesses a stock of orbital momentum large enough to intimate for it an analogous history. The planetary attendants travel nearly in their original tracks; the fluid ripples raised by them on the surfaces of their primaries lacked power to displace them. Their own rotation, indeed, seems to have been completely destroyed. Destroyed, that is, relatively to the destroying body. There is a certainty that some, there is the strongest likelihood that all of the Jovian and Saturnian satellites turn unchangingly the same face inward. They rotate in the periods of their several revolutions, just as our moon does, and as a consequence of the same cause. Tidal friction, however, appears to have been otherwise of subordinate importance in shaping their dynamical relations.

The agency will not, then, serve in all cases for a *deus ex machinâ*. It is not indiscriminately efficacious. The modes of its action have, in each of the systems considered, to be delicately distinguished. The stage of development arrived at by the globes affected, their degree of viscosity, their comparative mass and bulk, their modes of motion, all avail profoundly, and it may be incalculably, to modify the outcome. The facility of error in estimates of the kind is illustrated by Professor Darwin's remark that the magnitude of the tide-raising force is only one factor of the product.* The other is relative movement. Now, in the case of the moon, the former continually augmented retrospectively, while the latter fell off. Tidal generative power varies inversely as the cube of the distance; in antique times, then, when the earth and moon revolved contiguously, the bodily distortions they mutually produced must have been on an extremely large scale. Yet, because of the near coincidence of the periods of the globes, they must have been almost inoperative for frictional purposes. The travelling of the piled-up matter over their surfaces was too slow to lend it much efficiency as a friction-brake. The insignificant waves raised by the sun were, we are led to believe, because of their swift relative motion, more influential at that early epoch in checking terrestrial rotation than the colossal, but nearly stationary, waves due to the moon.

Numerical calculations, where they are practicable, afford the only safe guide to this intricate field of enquiry. It does not suffice to show that tidal action would have been of the kind required—would have taken the right direction—for bringing about some apparently anomalous result. Proof must besides be forthcoming that the action would have been of adequate power. Plausible guesses on the subject may be entirely fallacious. The machine, even if properly constructed for the end in view, may work too feebly for its attainment. We are, for instance, assured that no difficulty connected with the sense of planetary rotation need impede acceptance of the theory of planetary origin from separated rings, since even if the embryo globes gyrated the wrong way at the outset, solar tidal friction would promptly have reduced them to conformity with the general current of movement. This is true in principle; but will it bear quantitative investigation? Many promising hypotheses have broken down under the weight of figures; whether this particular one is strong enough to survive their application remains to be seen. We are, indeed, sure of its validity as regards Mercury, but the efficacy of tidal friction decreases as the sixth power of increasing distance, and the actual rotation of Venus furnishes an enigma sufficiently perplexing to discourage scrutiny of its dimly discerned antecedent conditions. As regards the earth and the exterior planets, the question could only be answered with the help of information which is not forthcoming.

Prof. Darwin's researches were fruitful just because they were definite. They demonstrated, once for all, the power of tidal friction as a cosmogonic agency, and indicated clearly the departments of cosmogonic change in which its competence lay. They availed, moreover, to determine for the earth-moon system the amount of work actually done by tidal friction in these several departments, and to prove its large excess over the corresponding output in any other sub-system falling within the sphere of observation. This memorable result suggests that our terrestrial home may be singular, not only in its evolutionary history, but in the innumerable adjustments fitting it to be the abode of life.

The relations of the earth and moon adumbrate, and scarcely more than adumbrate, the physical influences mutually exerted upon each other by numerous twin-globes in stellar space. Tidal friction is of maximum power in systems formed of equal masses; and those of double stars are seldom widely disparate. Most, if not all of them, were, besides, primitively very near neighbours; so that their symmetry must have been marred by conspicuous tidal deformations. The results upon their development have been expounded in detail by Dr. See. One of the most remarkable is the high average eccentricity of their orbits. Visual binaries, with few exceptions, travel in considerably elongated ellipses, while spectroscopic binaries usually pursue sensibly circular paths. Dr. See's argument that their eccentricity was acquired during the process of separation, under the influence of tidal friction, is well-nigh irresistible. True, this line of explanation is

* *Phil. Trans.*, Vol. CLXXI., p. 876.

not wholly clear of obstacles and incongruities. Yet they may probably be described as of a complicating, rather than of a contradictory kind. The theory of tidal friction is not an universal solvent of the difficulties encountered in the study of double stars. That the mode of action it deals with had a contributory share towards regulating their mechanical arrangements may, nevertheless, be regarded as certain, while the energy, and perhaps even the manner of its operation, varied extensively from system to system. What precisely it effected in each lies beyond our reach to determine. For the data available regarding the viscosity, density, and axial movements of fledgeling star-pairs must always be too scanty and insecure to provide a basis for rigorous computations. The mystery of the fore-time can never be entirely dissipated. Enough if we can look at it through a glass which darkens, without distorting, the objects presented in its field of view.

STELLAR SATELLITES.

By J. E. GORE, F.R.A.S.

THE term satellite is usually applied to the moons which revolve round the planets of the solar system, like our own moon and the moons of Jupiter and Saturn. But the term is also sometimes used with reference to the faint companions of bright stars. In most of the known binary, or revolving double stars, the component stars which form these stellar systems are usually of nearly equal brightness, or at least do not differ very much in relative brilliancy. These may be called pairs of suns, or "twin suns." There are, however, some notable exceptions to this rule. Among those binaries for which orbits have been computed the following are the most remarkable:—Procyon, magnitudes 0·5 and 13 (or 12½ magnitudes difference in brightness); Sirius, magnitudes 1·62 and 10 (about 11⅓ magnitudes difference); δ Cygni, 3 and 8; 99 Herculis, 6 and 11; 85 Pegasi, 6 and 10; and η Cassiopeiæ, 4 and 7·6. Of those double stars which are known to be binary, but in which the motion hitherto has not been sufficient to enable an orbit to be computed, the following may be mentioned:—θ Ursæ Majoris, 3 and 14; α Ursæ Majoris, 2 and 11; β Leporis, 3 and 11; ι Ursæ Majoris, 3 and 10; η Geminorum, 3 and 10; 34 Pegasi, 6 and 12; and 26 Draconis, 5½ and 11.

According to an orbit computed by Dr. See, and a parallax of 0″·38 found by Sir David Gill, the mean distance of the companion of Sirius from the bright star is about 21 times the earth's distance from the sun, or a little more than the distance of Uranus from the sun. The mass of the system is 3·47 times the sun's mass, the bright star being 2·36 times, and the satellite 1·11 that of the sun. With the above distance I find that the satellite, as seen from Sirius, would shine with about the brightness of full moonlight. As the mass of the satellite is about the same as that of our sun, its inherent light must be very small. If the sun were placed at the same distance from the earth its light would still be more than 1300 times that of the full moon.

The bright star Procyon forms a very similar system to that of Sirius. A close companion was strongly suspected by Otto Struve in 1873, and this was discovered in November, 1896, by Schaeberle with the great 36-inch telescope of the Lick Observatory. It is about the 13th magnitude. Dr. See finds a period of about 40 years, or about the same as that found by Auwers in 1861, from a consideration of some irregularities in the proper motion of Procyon. Dr. See finds the mean distance to be 21 times the sun's distance from the earth, and the mass of the satellite equal to that of the sun, or the same as in the Sirian system. The proper motion of Procyon is about the same as that of Sirius—1·3 seconds of arc per annum—and its parallax about 0″·32, only slightly less. The similarity of the two systems of Sirius and Procyon, in almost every particular, is very curious. The spectrum of Procyon is, however, of the second or solar type, and its mass about double that of Sirius. As Sirius is considerably brighter than Procyon (about two magnitudes), we have here another proof that stars with the solar type of spectrum have a larger mass in proportion to their brilliancy than stars of the Sirian type, or, in other words, of two stars having the same mass, but one with a Sirian and the other with a solar spectrum, the Sirian star would be much brighter than the solar one.

The 6th magnitude star 85 Pegasi has a "satellite" of the 10th magnitude. It is a binary star, and Dr. See finds a period of 24 years, with a mean distance of 0″·89. Burnham finds 25·7 years, and 0″·78. The proper motion of the system is about 1″·3, and a small parallax of 0″·054 was found by Brunnow. From these data I find that the mean distance is about 15 times the earth's distance from the sun. The orbits referred to above give the mass of the system from 4 to 8 times the sun's mass. The satellite as seen from the primary star would shine as a small sun, so that it must be considered rather as a companion sun than a satellite. The accuracy of the small parallax is of course somewhat doubtful, but if nearly correct the large proper motion would indicate a velocity of about 70 miles a second.

In addition to the above there are some stars which have faint companions "or satellites," the measures of which do not *directly* show orbital motion, but which are known to be physically connected, from the fact that the bright star and its faint attendant have the same "common proper motion." In other words they are moving together through space with the same velocity and in the same direction, and are therefore most probably near enough to be linked together by the laws of gravitation. In such cases the "satellite" probably revolves round its primary, but owing to the great distance from its central sun, the period of revolution would be very long, and the angular motion would not be perceptible for many years at the great distance at which the system usually lies from the earth. Let us consider some of these stellar systems. From the apparently great apparent distance which separates these satellites from the primary star, they seem to be constituted on a much vaster scale than those binary stars in which the motion is so rapid that an orbit can be computed. We will consider those stars for which a measurable parallax has been found, and for which, therefore, the distance from the earth is approximately known.

The bright reddish star, Aldebaran, has a faint satellite of about the 11th magnitude, at a distance of about 117 seconds of arc, which was originally discovered by Sir William Herschel. In the year 1888, this faint star was found to be a close double star by the famous American astronomer Burnham, with the 36-inch telescope of the Lick Observatory. He also found a closer and fainter companion—about the 14th magnitude—while using the 18½-inch telescope of the Chicago Observatory in the year 1877. The distance of this faint satellite from the bright star is about 31″. Measures in subsequent years have shown that the distant double companion is not moving with Aldebaran, which has a proper motion of about 0″·19 per annum, but, curious to say, Burnham's faint companion has, notwithstanding its comparatively great distance from Aldebaran, *exactly* the same proper motion as the bright star, and is therefore most probably

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physically connected with it. The result of this is that Herschel's distant companion is being gradually left behind—at least for the present—while Burnham's companion is accompanying Aldebaran in its flight through space. A parallax of 0″·107 was recently found for Aldebaran at the Yale University Observatory, U.S.A. Assuming this parallax and the above proper motion, the velocity of Aldebaran at right angles to the line of sight comes out about five miles a second.* The double companion has a proper motion of its own in a slightly different direction, amounting to about half that of Aldebaran. As this proper motion, small as it is, is an unusually large one for so faint a star, it has been suggested by Prof. Barnard that possibly its apparent motion may be really due to orbital motion round Aldebaran. However this may be—and time alone can decide the question—there can be no doubt that Burnham's faint satellite is physically connected with Aldebaran, and that the double companion also forms a physical system of its own. These facts render Aldebaran and its companions an interesting object of study.

Assuming that the line joining Aldebaran and Burnham's faint companion is at right angles to the line of sight—an assumption which would give the *minimum* distance between them—I find that the distance of the satellite from Aldebaran is about 300 times the earth's distance from the sun. Placed at this great distance from its central sun (10 times the distance of Neptune from our sun), the period of revolution round Aldebaran would be very long, and it is not a matter for surprise that no relative motion has been detected in the 25 years which have elapsed since its discovery. It will probably be many years more before its motion round its brilliant primary will become perceptible. Were our own sun placed at the distance of Aldebaran, I find that it would be reduced in brightness to a star of about the 5th magnitude, or about 40 times fainter than Aldebaran appears to us. This indicates that Aldebaran is a more massive sun than ours, and by its greater attractive power it may be able to control the motion of its distant satellite. As light varies inversely as the square of the distance, if we know the distance of Aldebaran from the earth and the distance of the satellite from Aldebaran, we can easily compute the brightness of the satellite as seen from Aldebaran, or from some planet revolving close to the bright star. Making the necessary calculation, I find that the light of the satellite would be increased by 19 magnitudes, if seen at the distance of 300 times the sun's distance from the earth. Hence, as seen from Aldebaran, the satellite would shine as a star of -5 magnitude, that is 5 magnitudes, or 100 times brighter than a star of zero magnitude, like Arcturus, or somewhat brighter than Venus is seen by us at the time of her greatest brilliancy.

A somewhat similar case is that of Regulus (α Leonis). This bright star has a satellite of about $8\frac{1}{2}$ magnitude at a distance of about 177″. This was found to be double by Winlock, the companion being of the 13th magnitude and distant about 3″ from the $8\frac{1}{2}$ magnitude star. Burnham's measures show that this double companion is moving through space with Regulus, the common proper motion being 0″·267 per annum. A small parallax of 0″·022 was recently found for Regulus at the Yale Observatory. With these data I find that the distance of Regulus from the earth is 9,375,000 times the sun's distance from the earth, and the $8\frac{1}{2}$ mag. star is at a distance from Regulus of about 8000 times the same unit. From this it follows that the $8\frac{1}{2}$ mag. star, as seen from Regulus, would shine as a star of $-6\frac{1}{2}$ magnitude, or about 8 times brighter than Venus at her brightest. The 13 mag. star would appear as a star of -2 magnitude, or somewhat brighter than Sirius as seen by us. The combination of a star 8 times brighter than Venus with one as bright as Sirius, and about one degree apart, would form a fine spectacle in the sky of Regulus. Our sun placed at the distance of Regulus would, I find, shine as a star of about 8·3 magnitude, or about the same brightness as the satellite appears to us. The satellite is therefore probably as large as our own sun. The difference of about 7 magnitudes between Regulus and the sun at equal distances indicates that Regulus is over 600 times brighter than the sun. It must therefore be a very massive body, probably much larger than Sirius,* and may therefore be able to control the motions of a satellite even at the great distance of 8000 times the earth's distance from the sun. The parallax and proper motion of Regulus indicates that its velocity at right angles to the line of sight is about 36 miles a second.

The bright star Rigel (β Orionis) has a companion of the 8th magnitude at a distance of $9\frac{1}{2}$″, discovered by Sir William Herschel. This small star was found to be an exceedingly close double star by Burnham in 1871. The measures are not yet sufficient to enable an orbit to be computed, but Burnham thinks that the period may possibly be very short. The measures of the 8th magnitude companion with reference to Rigel do not yet indicate any well-defined motion, but as it has the same proper motion as Rigel it is certain that there is a physical connection between them. The proper motion is small—about 0″·018 per annum. According to Sir David Gill, the parallax of Rigel does not exceed the hundredth of a second, or 0″·01. Assuming this parallax, the distance of Rigel would be at least 20 million times the sun's distance from the earth, and considering its great apparent brilliancy (0·28 magnitude) it is probably a sun of enormous size. Placed at the distance indicated by the above parallax the sun would, I find, be reduced to a star of about the 10th magnitude. A parallax of 0″·01 would place the satellite at a distance from Rigel of 950 times the sun's distance from the earth. At this distance its magnitude as seen from Rigel would be about $-13\frac{1}{2}$, or somewhat brighter than our moon appears to us.

The $4\frac{1}{2}$ magnitude star 0^2 (40) Eridani has a small companion of about the 9th magnitude, at a distance of about 82″. This satellite was found to be double by Sir William Herschel in 1783. It is a binary pair, and Burnham finds a period of about 180 years. It has the same large proper motion as the bright star, about 4″·1 per annum, and a parallax found by Hall of 0″·22. This gives a distance from the earth of 937,570 times the sun's distance, and a distance between the bright star and its binary companion of 372 times the distance of the earth from the sun. The measures of position show evident signs of orbital motion, but the period is probably very long, perhaps several thousand years. Placed at the distance of 0^2 Eridani, the sun would, I find, be reduced to a star of about $3\frac{1}{2}$ magnitude, or about one magnitude ($2\frac{1}{2}$ times) brighter than the star. I find that the binary satellite seen from its primary would give the light of a star of about -8 magnitude, or, in other words, the light of a small moon. The parallax and proper motion indicate a velocity across the line of sight of about 54 miles a second.

It was suggested by Sir John Herschel with reference to the faint companion of ι Ursæ Majoris, that it might possibly shine by light reflected from the bright star, and

* The motion *in* the line of sight seems to be much greater.

* Regulus has a spectrum of the Sirian type.

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PHOTOGRAPHS OF COMET *c* 1903 (BORELLY).

By ISAAC ROBERTS, D.Sc., F.R.S.

S.

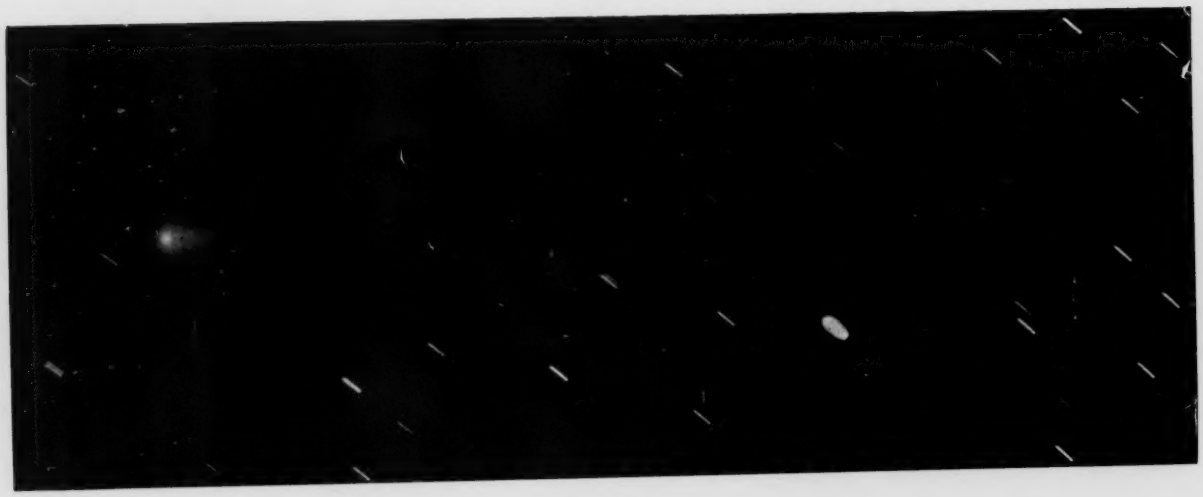

FIG. 1.

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FIG. 2.

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FIG. 3

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Admiral Smyth remarked, with reference to the double star Struve 946, "the possibility of the *comes* being variable awakens considerations of peculiar interest; it having been surmised that certain small acolyte stars shine by reflected light."* But it may be easily shown that this is highly improbable, if not impossible. Let us take the system of Sirius. In this case the satellite—although very faint for its computed mass—certainly does not shine by reflected light from Sirius. This will appear from the following considerations which I have carefully worked out. Assuming for a moment that the satellite shines merely by reflected light, let us see what its brightness would be as seen from the earth. According to the computed orbit and parallax of Sirius—which are probably as reliable as those of any binary star hitherto computed—the mean distance of the satellite from the bright star is a little more than the distance of Uranus from the sun. Let us assume this distance. (A greater distance would strengthen my argument.) As the computed mass of the satellite is about the same as that of the sun, let us assume that it has the same diameter or 866,000 miles (a smaller diameter would of course strengthen my argument), and let us take the diameter of Uranus at 33,000 miles—which is very near the truth. Now assuming the same "albedo," or reflective power for Uranus and the satellite of Sirius (the albedo of Uranus is very high), we have the satellite, as seen from Sirius, shining with a greater brilliancy than Uranus as seen from the sun in the proportion of 866,000 squared to 33,000 squared, or as 688 to 1. This is on the assumption that Sirius and the sun are of equal brightness. But from the photometric measures of Sirius, and its known distance from the earth, I find that Sirius is at least 20 times brighter than our sun. We must, therefore, increase the above ratio 20 times to obtain the illumination of the satellite by the light of Sirius. This gives $688 \times 20 = 13{,}760$. That is, the satellite as seen from Sirius would be about 13,760 times brighter than Uranus as seen from the sun. This number corresponds to 10·3 stellar magnitudes. Now, taking the magnitude of Uranus, as seen from the sun, at 5·8 (which must be very near the truth), we have the brightness of the Sirian satellite, as seen from Sirius, equal to $5{\cdot}8 - 10{\cdot}3$, or $-4{\cdot}5$ magnitude, that is, $4\frac{1}{2}$ magnitudes brighter than a star of zero magnitude, like Arcturus, or slightly brighter than Venus appears at her greatest brilliancy as seen from the earth. Now, the the simple problem is this: if a body shines with a stellar magnitude of $-4{\cdot}5$ as seen at the distance of Uranus, what would be its magnitude if placed at the distance of Sirius? Taking the parallax of Sirius at 0″·38, we have its distance from the earth equal to 542,800 times the sun's distance from the earth. Hence the light of a body at the distance of Uranus would, if removed to the distance of Sirius, be reduced in the proportion of the square of 542,800 to the square of 19, or as 816,244,900 to 1. This corresponds to 22·3 stellar magnitudes. Hence the magnitude of the satellite of Sirius, as seen from the earth—*if shining only by reflected light from Sirius*—would be $22{\cdot}3 - 4{\cdot}5$, or 17·8 magnitude, and it would therefore be quite invisible in the great 40-inch telescope of the Yerkes Observatory, even if seen on a dark sky, the smallest star visible in that telescope being about the 17th magnitude. As its actual brightness is about the 10th magnitude, it follows that it is about 1300 times brighter than if it shone merely by reflected light, and it is evident that it must have some inherent light of its own. I have shown in the beginning of this paper that the actual brightness of the satellite, *as seen from Sirius*, is equal to that of full moonlight on the earth. We should obtain a very similar result if we assumed that Sirius is very much brighter than 20 times the brightness of the sun. If we assume it to be 10 times brighter than this, or 200 times the sun's brightness—a very improbable supposition—we should still have the satellite reduced to about the 15th magnitude, and placed as it is so close to such a brilliant star as Sirius, it would probably still remain invisible in our largest telescopes. The assumption I have just made is, however, quite inadmissible, for if we increase the light of Sirius we must increase its distance also, and this would further diminish the computed light of the satellite. We may, therefore, dismiss the idea that the satellite of Sirius could possibly shine merely by reflected light from its primary. The same considerations will apply to the case of Procyon and its satellite, and with greater force, as the satellite of Procyon is about three magnitudes fainter than the Sirian satellite, and Procyon is a less luminous sun than "the monarch of the skies."

* *Bedford Catalogue*, p. 155.

PHOTOGRAPHS OF COMET *c* 1903 (BORELLY).

By ISAAC ROBERTS, D.SC., F.R.S.

THE comet was discovered on the 21st of June by M. Borelly, at the Observatory of Marseilles, and the fact was immediately communicated to the *Central-Stelle* at Kiel, from which centre Prof. Kreutz distributed the information to all the principal observatories in Europe and in America. Ephemerides of the positions and orbit of the comet were quickly issued, by aid of which astronomers could follow its movements in the sky and make their observations upon it.

The three photographs annexed hereto were taken on the 24th and 26th July, when the comet was seven days past that part of its orbit where it was computed to attain the maximum brightness, namely, 14·6 times brighter than on the day of its discovery. On the 24th July, when the photograph, Fig. 1, was taken, the brightness had diminished to about 11·0 times, and on the 26th, when the photos Figs. 2 and 3 were taken, the brightness had further diminished to about 9·8 times, and the light will continue to decrease till the comet again will be invisible.

Figs. 1 and 3 on the plate were taken with the Cooke 5-inch lens, the exposures being (1) 45 minutes, (3) 60 minutes; scale about 122″ of arc to 1 millimètre; the length of the part shown of the tail is about six degrees, but if the plate had been larger the tail would have been shown to be considerably greater in length.

If we compare Fig. 1 with Fig. 3 it will be seen that the tail has undergone a remarkable change in outline, in structure, and in density, during the interval of two days, and that the gap of about one and a half degrees in length from the head had almost closed up, and the tail had assumed a more symmetrical form of straight streamers and of apparent nebulous matter, but they are too faint to be fully shown on the print.

Fig. 2. This photograph was taken with the 20-inch reflector simultaneously with No. 3; the scale in this case being about 43″ of arc to 1 millimètre. It shows more clearly the structure of the tail than can be seen with the 5-inch lens. The length of the tail is about $2\frac{1}{4}$ degrees, for the plate was too small to show more of it, but the structure is well seen, consisting of streamers and vacant spaces between them. Unfortunately the bad weather and moonlight nights have prevented more photographic evidence being obtained at Starfield of this interesting comet.

The nucleus was strongly stellar, but the surrounding *coma* did not indicate any structural details. If the threefold classification of comets should be reliable, the three

forms of tails that pertain to them would indicate the presence of hydrogen, hydro-carbon, and iron in this one, but spectroscopic evidence will be necessary to prove this suggestion.

CYCLES OF ECLIPSES.

By A. C. D. CROMMELIN.

THE computation of the circumstances of eclipses is such a laborious operation that it is not surprising that a great amount of energy has been directed, both in ancient and modern times, to the search for cycles after which the eclipses would recur with some or all of their features reproduced. Were an exact cycle discovered, we should be able, after calculating or observing all the eclipses of a single cycle, to deduce the conditions of all past and future eclipses.

For a cycle to be perfect it would require to satisfy five conditions, which we shall denote by the letters A, B, C, D, E. It should be an exact multiple:

A. Of the *lunation* or period of 29·53058844 days between one new moon and the next.

B. Of the *draconitic month* or period of 27·21221993 days between successive passages of the moon through either of her nodes.

C. Of the *anomalistic month* or period of 27·55455173 days between successive passages of the moon through her perigee.

D. Of the *solar year* or period of 365¼ days. As this condition is not so important as A, B, C, it is an unnecessary refinement to distinguish between the three kinds of years—sidereal, tropical, and anomalistic.

E. Of the solar day of 24 hours.

It is to be noted that the periods in A, B, C, are subject to variations; the values given are their *average* lengths according to Newcomb, at the epoch A.D. 1800. They are subject to slight variations in the course of centuries, but the effect of these will only be considered in the case of one period, the Megalosaros.

If we could find a period satisfying conditions A, B, C, D, E, we should have a perfect eclipse cycle. All the circumstances would be reproduced, even to the regions of the earth's surface from which the various phases are visible. The cycle would be rendered still more perfect from the circumstance that, owing to the exact restoration of the configurations of the three orbs concerned, all the more important lunar perturbations would return to their original values.

It may be said at once, however, that *no such perfect eclipse cycle exists*. Even could we find a perfect cycle of immense length, longer than the period covered by history, it would be of no practical use.

In the absence, then, of a perfect cycle, we have to be content with compromise, and examine how nearly the five conditions can be satisfied.

A must be rigorously satisfied in all eclipse cycles;

B must also be fairly exactly satisfied, since otherwise the eclipse will undergo a rapid change of character, and will disappear after a few returns;

C is the test of a good and useful cycle. Unless it be satisfied, it is impossible to deduce the character of a coming eclipse as regards totality or annularity, or to make any estimate of the longitudes of the regions over which its track will pass.

D. It is desirable that this should be fairly well satisfied, but it is less important than C, as the orbit of the earth round the sun is much more nearly circular than that of the moon round the earth.

E. This is the least important of the five conditions. The effect of its non-fulfilment is to shift the regions of visibility eastward or westward on the earth's surface; but this is a very simple matter to allow for, if the other conditions are satisfied.

It may be noted that where C is not satisfied, the irregularities thus arising in the Moon's longitude are so large that the discussion of condition E becomes quite meaningless. Hence in the schedule below, the word "Zero" is inserted in the 12th column in those cycles where C is not satisfied, at least approximately.

The cycles that we shall discuss in this paper are six in number:—The 4 year cycle (4^y); the Saros (Sar.); the Stockwell cycle (St.); the 300 year cycle (300^y); the ninefold Stockwell cycle (9 St.); the Megalosaros (Meg.). The abbreviated designations indicated in brackets will be used to save space.

It appears the more useful and concise plan to first give accurate statistics of the various cycles in the form of a schedule, and then to proceed to a verbal description of each in turn—its discovery, its value, its special features and characteristics.

The second column gives the length in ordinary years and days; this necessarily varies with the number of leap years included, and so is only approximate.

The fourth column gives the length in days and fractions. Dividing this length by the values of the draconitic and anomalistic months, we obtain columns (5) and (8). The nearer these columns are to exact integers the better the cycle.

The difference between the 5th column and an exact integer multiplied by 360 to reduce it to degrees gives us the 6th column. A solar eclipse is possible (on the average) when the new moon occurs, when the moon is within 16°·3 of the node, *i.e.*, along an arc of 32°·6 of the orbit. Hence we divide 32°·6 by the number of degrees in the 6th column, and so obtain the number of cycles for which an eclipse persists, which is given in the 7th column. The number thus obtained is an index of the accuracy with which condition B is satisfied. The great feature of the Stockwell cycle is the extreme accuracy with which this condition obtains; indeed, it suffices to cover the whole historical period, since the entire life-history of an eclipse would be over 20,000 years.

Of course, the test of condition E is simply that the length of the cycle should be nearly an exact number of days.

Mr. Maunder has traced out the life-history of a solar eclipse in the Saros cycle in KNOWLEDGE for October, 1893. Much of what he states there holds not only for the Sar. but for all eclipse cycles.

Thus in all the cycles an eclipse begins as a small partial eclipse near one of the earth's poles, and continues partial for about one-sixth of its whole career, the magnitude of course increasing at each return. It then becomes central (either total or annular), the track passing near that pole of the earth where the partial phase began. The tracks approach the equator at each return; the eclipse reaches the climax of its vigour when the sun is exactly overhead at mid-eclipse, and after that the track gradually approaches the opposite pole. When this is reached the eclipse ceases to be central. Its dissolution is the exact converse of its birth. It is thus partial for one-sixth, central for two-thirds, and again partial for one-sixth of its career. For example, in the 4^y cycle we should have four partial eclipses followed by fifteen central ones, and then four more partial ones; similarly in the other cases. The numbers thus obtained are *average* numbers; they may be considerably affected by the eccentricity of the orbits of the sun and moon.

It is important to know whether the tracks will move northward or southward in any particular cycle; this is decided by observing whether the number of drac. months in column 5 exceeds or falls short of an exact integer. If the former, then, at an eclipse near the ascending node, the moon will be further north at each succeeding return of the eclipse, and consequently the track on the earth's surface will also move northward. By reasoning of this kind we deduce the following laws:—

In the 4^y St. 9 St. } Ascending, or in the Node Eclipses Sar. 300^y } Descending. Node Eclipses The tracks on the earth move north.

On the other hand—

In the 4^y St. 9 St. } Descending, or in the Node Eclipses Sar. 300^y } Ascending. Node Eclipses The tracks on the earth move south.

The Meg. requires special discussion, in consequence of the secular changes.

To quote Mr. Maunder's article: "Each [eclipse in the Sar. cycle] is born as the second member of a pair of eclipses; each dies as the first member of such a pair." This relation also holds good in the 300^y; but in the 4^y and the St. the converse is the case; in these an eclipse begins its career as the first of a pair of partial eclipses one month apart, and dies as the second of such a pair.

There is another interesting point that we may consider before passing to the separate discussion of the individual cycles; that is, "What happens at the half-cycle?" If the number of lunations be even, and the number of drac. months even, we have a solar eclipse at the same node at the half-cycle; if the first be even and the second odd, we have a solar eclipse at the opposite node at the half-cycle. (This is the case in the St., so that we have a similar solar eclipse at the opposite node, and with the track in the opposite hemisphere of the earth after 29^y. In fact, Mr. Stockwell defined his cycle as a 29^y one, but I have preferred to use the double cycle, so as to return to the same node again.)

If the number of lunations be odd, of drac. months even, we have a lunar eclipse at the same node at the half-cycle (this holds in the Sar.); lastly, if both the numbers be odd, we have a lunar eclipse at the opposite node at the half-cycle (this holds in the 4^y and 300^y).

In all cases the half-cycle eclipse reaches its maximum vigour about the same time that the original eclipse does.

SCHEDULE OF ECLIPSE CYCLES.

(1) Cycle.	(2) Approximate Length.	(3) No. of Lunations.	(4) Length in days.	(5) No. of Drac. months.	(6) Corresponding separation of New Moon from Node.	(7) Average number of times an eclipse returns.	(8) No. of Anom. months.	(9) How the criteria are satisfied. B	(10) C	(11) D	(12) E
					°						
4^y	4^y less $2m \odot 12^d = 3\frac{1}{4}^y$	47	1387·9377	51·00421	1·515	23	50·37054	Fair	Bad	Bad	Zero
Sar.	18^y $11\frac{1}{3}^d$	223	6585·3212	241·99868	0·476	70	238·99212	Good	V. Good	V. Fair	Good in trip. Saros
St.	58^y less $40^d = 57\frac{8}{9}^y$	716	21143·9013	777·00023	0·083	390	767·34691	V. Good	Bad	Poor	Zero
300^y	300^y less 44^d	3709	109528·9525	4024·99145	3·078	12	3974·98582	Poor	Good	Poor	Good
9 St.	521^y 4^d	6444	190295·1117	6993·00207	0·745	43	6906·12221	Good	Poor	V. Good	Fair
Meg.	1805^y 8^d	22325	659270·3869	24228·99761	0·860	39	23926·00661	Good	Good	Good	Bad
Ditto in -700	,,	,,	659270·5472	24227·00280			23925·98205				

The 19-year period enables us to tell immediately whether any solar eclipse in Oppolzer's Canon is at the ascending or descending node. In the former case the tracks move steadily northward each 19-year period, in the latter case they go southward.

As an example of this cycle I trace the career of the Norwegian eclipse of 1896; this is in its hoary old age viewed according to the Sar., but in early youth according to our present cycle. The following table gives the principal features of this series (desc. node), also of the half-cycle lunar eclipses (asc. node):—

SOLAR ECLIPSES.

Date.	Character.	Position of Track.
1877, Aug. 9	N. Part.	
1881, May 27	N. Part.	
1885, Mar. 16	Ann.	West Canada. Greenland.
1889, Jan. 1	Tot.	North Pacific, United States (West).
1892, Oct. 20	N. Part.	(Almost Annular).
1896, Aug. 9	Tot.	Norway, Siberia, Japan.
1900, May 28	Tot.	Mexico, U.S.A., Spain, North Africa.
1904, Mar. 17	Ann.	Indian Ocean, Sumatra, Philippines.
1908, Jan. 3	Tot.	Central Pacific.
1911, Oct. 22	Ann.	China, Philippines, New Guinea.
1915, Aug. 10	Ann.	Central Pacific.
1919, May 29	Tot.	Brazil, Equatorial Africa.
1923, Mar. 17	Ann.	Patagonia, South Africa.
1927, Jan. 3	Ann.	South Pacific, South America.
1930, Oct. 21	Tot.	South Pacific.
1934, Aug. 10	Ann.	South Africa, South Indian Ocean.
1938, May 29	Tot.	South Atlantic, South Indian Ocean.
1942, Mar. 16	S. Part.	
1946, Jan. 3	S. Part.	
1949, Oct. 21	S. Part.	
1953, Aug. 9	S. Part.	

LUNAR ECLIPSES.

Date.	Character.	Limb of Moon Eclipsed.	Magnitude.
1883, Apr. 22	Part.	N. Limb	0·27
1887, Feb. 8	Part.	N. Limb	0·44
1890, Nov. 26	Part.	N. Limb	0·00
1894, Sep. 15	Part.	N. Limb	0·26
1898, July 3	Part.	N. Limb	0·93
1902, Apr. 22	Tot.	...	1·33
1906, Feb. 9	Tot.	...	1·64
1909, Nov. 27	Tot.	...	1·37
1913, Sep. 15	Tot.	...	1·44
1917, July 4	Tot.	...	1·37
1921, Apr. 22	Tot.	...	1·09
1925, Feb. 8	Part.	S. Limb	0·76
1928, Nov. 27	Tot.	...	1·17
1932, Sep. 14	Part.	S. Limb	0·99
1936, July 4	Part.	S. Limb	0·28

PART II.

THE FOUR-YEAR CYCLE. — The one merit of this cycle is its extreme shortness; it does not reproduce eclipses with any attempt at accuracy, but it is a convenient aid to the memory in connecting together the eclipses of different years, and in determining which years are likely to yield important eclipses. It bears an intimate relationship to Meton's famous 19-year cycle, after which new moons recur on the same days of the month (or sometimes with an alteration of one day). Since the Greeks were acquainted with this cycle, and also with the fact that the moon's nodes make the tour of the heavens in 18·600 years, they probably perceived that an eclipse was usually followed by one on the same day 19 years later. I do not know who was the first to perceive that one-fifth of the Metonic cycle was an eclipse period, but several people have noticed it independently in recent years.

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Of course the irregularities in this cycle, *e.g.*, those of 1889, 1892, 1925, 1928, are due to the fact that conditions C, D are totally unsatisfied. For the same reason this cycle gives us no clue to the longitude of an eclipse track, or to the time of day at which the eclipse occurs.

There is a point in which this 4^y cycle may sometimes be of use. The last of a series in the 4^y is frequently the first of a Sar. series; when this is the case the 4^y serves as an index, calling our attention to the birth of a new eclipse in the Sar. It is not the case in 1953, for that eclipse is born two Saroses earlier, in 1917.

THE SAROS.—This cycle was discovered by the ancient Chaldæans, at a very early date, and it still remains the most perfect and serviceable of all eclipse cycles, on account of the wonderful accuracy with which conditions B, C, D are satisfied. We can, in fact, get a very fair idea of a coming eclipse without any calculation at all, by tabulating the preceding ones of the series and carrying on the differences. This appears to have been the way that the Chaldæans predicted their eclipses.

Mr. Maunder's paper, above referred to, has dealt so fully with this cycle that it is unnecessary to add much here. It may, however, be interesting to give a diagram showing the tracks of a series of eclipses, and I have chosen the series to which the eclipses of 1927, 1999 (both total in England) belong. This began its career as a small northern partial eclipse, 1639, January 4, and increased slowly each Sar.; its companion eclipse (one month earlier) lingering till 1837, April 5. Our eclipse became central, 1891, June 6 (some readers may remember this eclipse as the one visible from the Royal Observatory on Visitation Day), but the tracks of 1891 and 1909 are too far north to show conveniently. The diagram begins with the eclipse of 1927, and shows all the tracks till 2179. Even this date is not quite the middle of the series, but that is only a few Saroses later.

The southward motion of the tracks is affected by the season of the year, which accelerates it from June to December, and retards it for the other half-year. The slope of the tracks also varies with the season. The western end of the track is the highest from June to December, then the eastern end from December to June. The tracks will continue to move southward, and the eclipse will cease to be central about the year 2600, remaining partial for two or three centuries more.

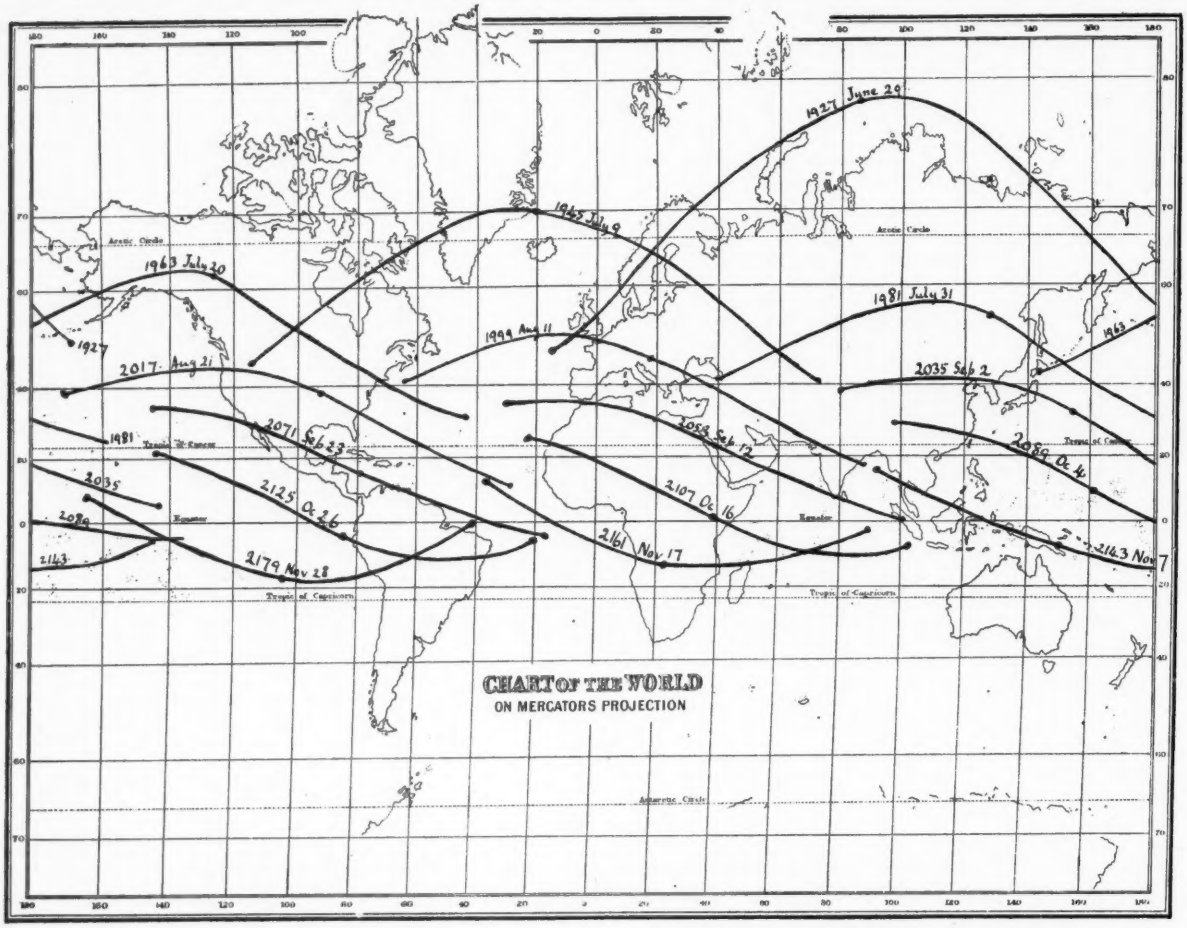

PLATE I.—Diagram illustrating the Saros Cycle. The tracks of a Total Eclipse are shown from 1927 to 2179.

The half-cycle lunar eclipse began its career 1900, June 13 (north limb); it becomes total 2044, September 7, and reaches its climax about the same time as the solar eclipse, ending about the same time as the latter ceases to be central.

It not infrequently happens that two eclipses, nine years apart, at opposite nodes, pass one another about the

latitude of Europe, and give large eclipses over approximately the same regions. As examples, may be given 1715, 1724 (both total in England); 1887, 1896 (Siberia and Japan); 1945, 1954 (Norway), etc., etc. This is not sufficiently regular to be called a law, but it is worth while seeking in any European totality, whether there is another one nine years before or after.

It may be remarked that Mr. Maunder has considerably under-estimated the possible career of an eclipse in the Sar. He gives it as 71 returns, but according to Oppolzer it may reach 85 (as in the case of an eclipse that died in A.D. 676); there are seven cases of 80 returns or upwards in the Canon.

time. 1902 had three partial solar eclipses. Then follow a group of six central eclipses (two each in 1903,–4,–5). This year's eclipses are in their decrepitude, and end their career as central eclipses in 1957 and 1939 respectively. Next year's eclipses are in full vigour, while those of 1905 are in comparative youth and began their central career in 1598, 1797 respectively.

The Sar. may be used to give, without calculation, a rough position of the moon at any time in a year for which no Almanac is available. Thus, suppose we desire to obtain a rough place of the moon at 11 p.m. on March 21, 1921. We take from the Almanac its place one Sar. earlier.

[Note that the Sar. consists of $18^y\ 12\frac{1}{3}^d$ when three 29ths

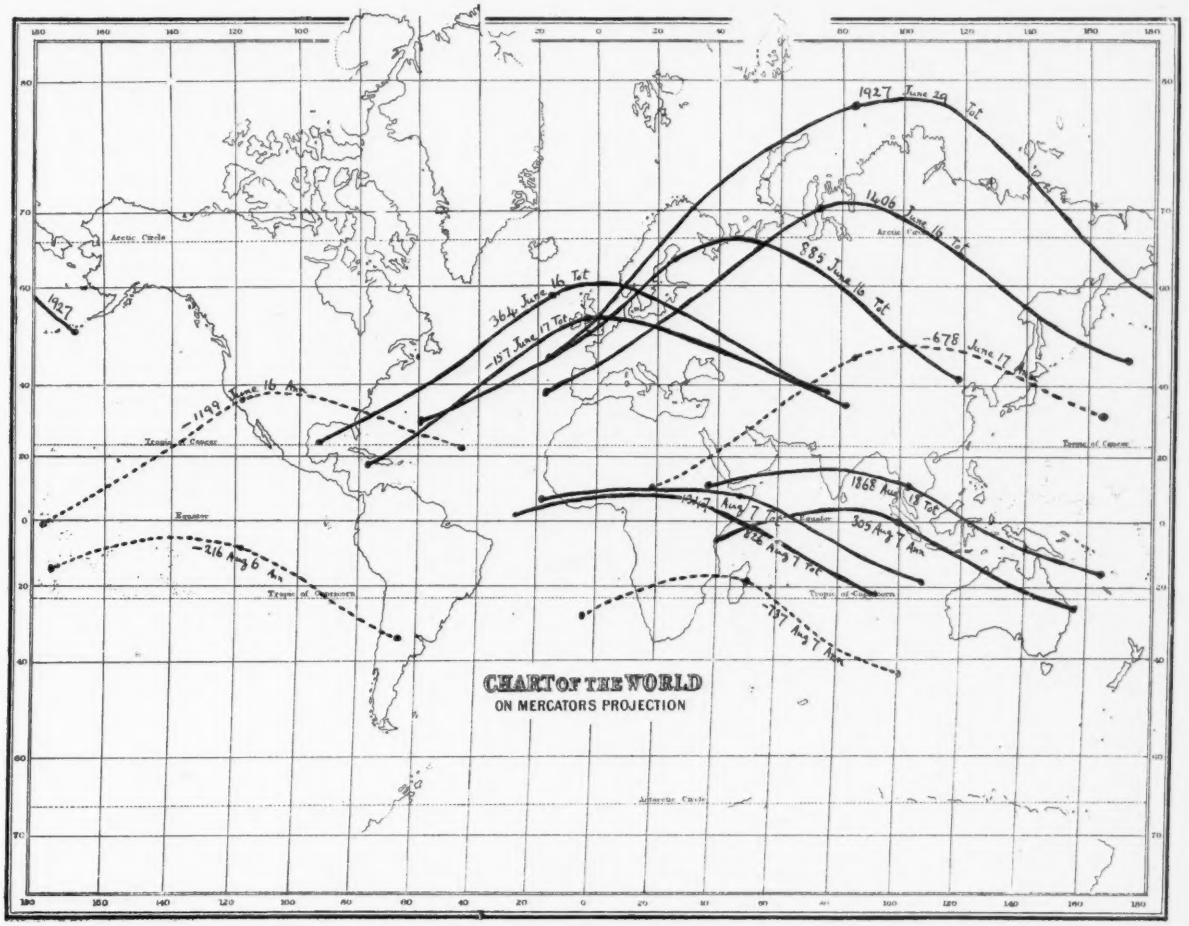

PLATE II.—Diagram illustrating the past history of the Eclipses of 1868 and 1927 in the 521-year Cycle.

The following is an easy way of diagnosing the approximate age of a central eclipse in the Sar.

A glance at Oppolzer will show that we have generally a group of partial eclipses (2, 3, or 4), followed by a group of central eclipses (4, 5, or 6), of course separated from one another by six months. Then we can infer that the central eclipses at the beginning of such a group are in their decrepitude, those in the middle of the group are in their full vigour, while those at the end of it have just began their central career. In a word we may apply the adage "Seniores priores" to the group, which is often a useful aid to the memory.

As an example we may take the eclipses of the present

of February are included in the interval, $18^y\ 11\frac{1}{3}^d$ when four are included, $18^y\ 10\frac{1}{3}^d$ when five are included.]

In this case five 29ths of February are included, hence the corresponding date is 1903, March 11^d 3 p.m.

We take from the Almanac the age of the moon at this time, viz., 12·2 days; this will also be its age at the epoch required in 1921.

We also take its R.A. and Dec., viz., R.A. $9^h\ 42^m\ 4$, N. Dec. 92° 27′, insert this on a star map, and then shift it eastward 10°·8 parallel to the ecliptic. The result is a close approximation to the place of the moon at the time named; in this case we obtain $10^h\ 20^m\cdot1$, N. Dec. 6° 3′.

As another example, the age of the moon at noon,

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March 8, 1899, was 26·1 days. Going back four Saroses we reach 1809, January 12^{d}·8^{h} p.m., when the moon's age would have been about the same. This was the date of the death of Sir John Moore, and we thus see that the lines "By the struggling moonbeams' misty light," in Wolfe's beautiful poem, are not strictly in accord with astronomical facts.

THE STOCKWELL CYCLE.—This is chiefly interesting for the extraordinary accuracy with which condition B is satisfied; it is not a good cycle in any other respect. The ninefold cycle is better, as it satisfies condition D accurately and C roughly. A diagram is given showing the past history of two eclipses in this cycle, viz., those of 1868, 1927.

It will be seen that several of the tracks repeat themselves very well; thus those of −157, 364, 885, 1406, 1927, are all total in or near the British Isles. We cannot, however, have great confidence in the longitude of a track predicted by this cycle: for example, the tracks of −1199, −678, also those of −737, −216, show a great shift in longitude. We can, however, predict the latitude very closely, as the diagram shows.

(To be continued.)

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE SURROUNDINGS OF THE "AMERICA" NEBULA.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—In the July number of KNOWLEDGE Dr. Max Wolf states: "Photographs of this fine nebula have been published not only by myself (KNOWLEDGE, 1902), but also within the last few months by Dr. Roberts and by Professor Barnard." I wish this statement, which is inaccurate so far as I am concerned, to be corrected. My photograph of the nebula was taken on October 10th, 1896, and was published in KNOWLEDGE, November number, 1898, which chronological computations would sum up to 81 months. This fact is not fairly represented by Dr. Wolf's words "within the last few months." I have also compared the photograph here referred to with mine published in 1898, and find vast differences, in favour of my reflector plate, in the structural details that are delineated. The letterpress which accompanied the photograph explained that the nebula extended beyond the boundaries of the plate.

Is it desirable, in these modern days, to attach the names of countries, towns, cities or of individuals to nebulæ or other objects in the sky? Of course we may excuse the harmless lunacy of designating by the names of individuals objects seen on the moon; but, if the practice is to be extended to the designation of objects which can be photographed in the sky, there should be some method of selection, and I do not see the reason of attaching the name of America more than of England to the nebula here referred to. It was first photographed, on a scale that is suitable for scientific investigation, at Starfield, but I should object to change its designation of H V. 37 *Cygni* because Sir William Herschel was the first to discover it; and, further, I object to all fanciful designations that may involve controversies.

Starfield, Crowborough. ISAAC ROBERTS.

PROTECTIVE RESEMBLANCE IN BUTTERFLIES.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—Some years ago I made a small collection of butterflies in the district of Santos, Brazil, and amongst them are two specimens obtained from the granite quarries, which in colour and markings exactly reproduce the texture of granite. I have no doubt this is an instance of ordinary protective resemblance, for I remember how difficult it was to see these butterflies when once they settled on the granite surface. The point, however, which strikes me as of considerable interest is that the general colouring of the butterfly is a cool blue grey, exactly the shade of the freshly-quarried stone, on which it invariably settled. The weathered surfaces of the granite were greenish-grey.

The facts seem to point to a very rapid evolution of the butterfly's present colouring, since the quarries in question have probably only existed for some 200 years, and before that time the butterflies could not have found access to a freshly-cleft granite surface.

I am not entomologist enough to name the butterfly, but would send a photograph to anyone interested.

I should be glad if any of your correspondents who have studied the question of protective colouring could say whether there is any warrant for concluding that a change in colour of the kind indicated could be evolved within so limited a period. W. S. ROGERS.

[This observation is of much interest, and there can be little doubt that the colour of the species has changed during the period mentioned under the influence of natural selection. During the last half of the nineteenth century British entomologists have noticed a distinct tendency on the part of certain moths, normally of a pale grey colour, to be replaced by dark varieties, in the manufacturing districts of the north of England, where the habitual resting-places of the insects—palings, tree-trunks, &c.—tend, through the deposition of soot, to be darker than usual. It must be remembered that a century or two is a comparatively long period in the life of a species of insect. —G. H. CARPENTER.]

CURIOUS SUNSET PHENOMENON.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—On the 4th July, I observed a curious phenomenon in conjunction with the sunset of that date. The sun was, roughly, at an altitude of ten degrees above the horizon at the time, and partially obscured by dense dark

clouds, which, together with a faint haze, hung over the low hills which bounded the horizon in that direction. At about 7 p.m. my attention was drawn to an exceedingly bright patch of light, of irregular shape, which exhibited

the spectrum colours with great distinctness (red nearest the sun), and appeared in the north-west, about thirty degrees from the sun and at the same altitude. From the time that I first noticed this (I had previously been looking in a different direction) the light diminished in brightness, and finally, after about fifteen minutes, faded away. The corresponding portion of the sky on the other side of the sun, *i.e.*, thirty degrees from the sun in a south-westerly direction, was not visible from my position, but I was unable to observe anything similar above or below the sun. There was no actual cloud where the light appeared, though there was just below it. The temperature was about 60° Fah., and on return to camp the barometer gave a reading of 24·56″ (altitude 5183 feet above sea).

I trust some reader of KNOWLEDGE will be able to explain this, and that some other Indian reader may record his impressions of this phenomenon.

K. D. FIELD, LT.R.A.

Kashmir.

Notes.

ASTRONOMICAL.—The interesting variable, or "new" star near the Ring Nebula in Lyra (designated 10, 1903 Lyræ), which was discovered some time ago by Herr E. Silbernagel, has been fully investigated at the Lick Observatory. Photographs taken by Prof. Keeler in 1899 show the star to have been then of the 17th magnitude, but in April of the present year it had risen to the 12th magnitude. A spectroscopic investigation made with the small slitless spectrograph shows the presence of bright lines, but in spite of this the spectrum has little similarity with that of novæ. The observations leave little doubt the star is a variable, and not a nova, and that it belongs to the class of variables which exhibit bright lines of hydrogen at maximum. The spectrum is, in fact, almost an exact counterpart of that of R Draconis. The position of the star (1900) is 18h. 50m. 27s. + 32° 42′ 21″.

The issue of "Bulletins" from the Lowell Observatory, Flagstaff, Arizona, is inaugurated by an interesting account of the observations of the projection on the terminator of Mars, which excited such general interest towards the end of May. From the micrometric measurements it appears that the projection, which was three hundred miles in length on May 26th, but had almost disappeared on the following day, travelled over the surface of the planet at the rate of sixteen miles an hour. It, therefore, could not have been the illuminated summit of a mountain, and Mr. Lowell concludes that it was an enormous cloud. He further expresses the opinion that it was not a cloud of water vapour but a cloud of dust, and he states that other phenomena of the planet bear out this supposition.

Additional evidence of the physical connection of the two components of 61 Cygni is furnished by a spectroscopic investigation of their movements in the line of sight which has been made by Mr. Adams at the Yerkes Observatory. The mean results are 62 and 63 kilometres per second, towards the sun, for the two stars, and this agreement, together with the similar proper motions of the two stars, indicate that they are unquestionably physically connected. Their real motion in reference to the sun, under the assumption of a parallax of 0″·4 and a proper motion of 5″·2, would be about 80 kilometres, or, in space, when corrected for the solar motion, about 64 kilometres per second.—A. F.

BOTANICAL.—One of the most interesting instances of irritability in plants is met with in *Masdevallia muscosa*, a diminutive orchid of no horticultural value, but remarkable in the sensitiveness of its labellum. The plant has been known for many years, and the peculiar character of the labellum was the subject of an elaborative paper in the first volume of the *Annals of Botany*, by Prof. F. W. Oliver. It was exhibited at the Royal Society's Soirée on June 19th, and may still be seen in flower in Kew Gardens. Its irritability may be compared to that of the Venus Fly Trap. In this, it will be remembered, the parts that receive the stimulus are the three bristles found on each half of the leaf-blade, and it seems to be conveyed from them to other points where the movement actually takes place. In the orchid it is the crest of the small triangular labellum that receives the stimulus, but the movement occurs at the narrowed base of this organ, called the neck, and the labellum is caused to spring upwards against the column, forming with other parts of the flower a small chamber having only a very narrow opening at the top. The purpose of the sensitive labellum is evidently to aid in the cross-fertilization of the flower. An insect on touching the crest is at once made a prisoner by the springing up of the labellum, but it eventually escapes by crawling through the aperture at the top of its prison. In doing this, however, it is obliged to brush against the pollinia, which it carries away, transferring them to the stigma of another flower while it is struggling to escape from a second term of captivity.

It is not uncommon for peduncles or pedicels to elongate a little after the flowering period, and during the ripening of the fruit; but to have a pedicel, which at the flowering stage is scarcely more than a quarter of an inch long, growing to a length of six or seven inches is a very unusual occurrence. This, however, takes place in a small parasitic orchid, *Didymoplexis pallens*, which is now to be seen in flower at Kew. The whole plant is usually less than six inches high, and the flowers are small, brownish white, and unattractive. The elongated pedicels are quite erect, and the remarkable growth in length is accompanied by a considerable increase in thickness; but it has been observed that only the pedicels of flowers which have been fertilized possess this peculiarity. The plant is widely spread in India, and is found also in Perak, growing in the bottoms of tropical valleys, usually under clumps of bamboos, on the roots of which it appears to be parasitic. The growth of the pedicel is supposed to be for the purpose of carrying the fruit well above the decaying vegetable matter in which the plant grows.—S. A. S.

ZOOLOGICAL.—In the article on giant tortoises published a few months ago in KNOWLEDGE, it was stated that the earliest known members of the group date from the Pliocene (or possibly the late Miocene). Recently, however, these reptiles have been carried back to a much earlier period in the earth's history by the discovery of the remains of a species in the upper Eocene formation of the Fayum district, Egypt. The remains of the species in question have been described by Dr. C. W. Andrews in the publications of the Cairo Survey Department, and named *Testudo ammon*. In addition to thus carrying back the existence of giant land tortoises to such a comparatively remote epoch, the discovery has a wider interest. For if creatures of such an essential modern type date from strata of undoubtedly Eocene age, there may be something to be said in favour of the view of the Argentine palæontologists as to the early Tertiary age of the mammaliferous beds of the Santa Cruz district of Patagonia, a

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view which has been generally discredited in Europe on account of the specialised character of the fauna.

According to Dr. R. Broom (*Proc. Linn. Soc. New South Wales*, 1902, p. 4), considerable modification must be made with regard to the homology of certain bones in the base of the skull of lizards and other reptiles and amphibians. Hitherto a pair of bones in the front of the skull have been correlated with the mammalian vomer. These, however, Dr. Broom calls prevomers, and identifies with the so-called dumb-bell bone of the duckbill; while the true vomer is represented by the large sheet-like bone on the hinder part of the base of the skull of amphibians hitherto known as the parasphenoid, this bone being also present in a rudimentary form in lizards.

In the *Zoologist* for July Mr. Lydekker described the Burmese representative of the gaur, or wild ox of India, as a new race, under the name of *Bos gaurus readei*; the chief distinctions from the typical race being the presence of a tuft of long hair on the dewlap and a difference in the form of the horns.

The form of the skull of the gigantic toothless pterodactyle (*Pteranodon*) of the Cretaceous of Kansas gives rise to the suggestion, according to Mr. G. F. Eaton (*Amer. Journ. Science*, July, 1903), that these monstrous flying reptiles were furnished with a capacious gular pouch, comparable to that of the pelicans. This is in accordance with the supposed fish-eating habits of *Pteranodon*.

Great interest attaches to the discovery, during excavations in the base of a house in Salisbury Square, E.C., of the nearly perfect skull, minus the lower jaw, of the woolly Siberian rhinoceros. The specimen, which was found in a bed of peat, is reported to be the finest and the most nearly complete ever discovered in this country, being rivalled in this respect only by examples from the Siberian tundra. At a short distance from the skull were dug up a half of a lower jaw, the head of a thigh-bone, and a few ribs; the former, it is said, pertaining to a species other than the woolly *Rhinoceros antiquitatis*.

In a recent issue of the *Proceedings* of the Royal Society Prof. W. J. Sollas, of Oxford, demonstrates that the so-called Palæozoic lamprey (*Palæospondylus gunni*), from Devonian strata, is in reality a primitive fish-like creature, exhibiting signs of affinity with the lampreys, the sharks, and the young of lung-fishes or amphibians. It probably diverged from the main stem previous to the differentiation of the sharks and rays, and pursued an altogether independent line of development. Prof. Sollas's method of investigation was by making thin transverse sections of a number of specimens.

More than twenty years ago Prof. T. Eimer showed that among lizards the following changes in colour-pattern are very commonly observable. First there are longitudinal stripes, which break up into spots; the latter coalesce to form transverse bars, which finally disappear and leave the skin of one uniform tint. In some lizards the whole of these stages are passed through during life, but in others only the second or even the first stage is reached, while in yet others commencement is made with the second or some later stage. From these facts Eimer advanced the theory that the same series of colour-evolution has occurred in the animal kingdom generally. Recently Dr. H. Gadow, of Cambridge, in a paper contributed to the *Proceedings* of the Royal Society, has tested Eimer's observations in the case of certain Mexican lizards, and finds that in the main they hold good. It appears, however, that it is only in certain stations these changes take place, so that they are limited to particular races or breeds, in which, moreover, only some of them occur. It is believed that the changes are due to differences in the amount of light received in the habitat of these particular breeds, and therefore that they are protective in their nature.

If American methods are continued much further on the present lines, Zoology, so far at any rate as mammals are concerned, will become a well-nigh impossible science to all save specialists of the narrowest type. In addition to others named during past years, Mr. G. S. Miller has recently described no less than fifteen chevrotains, or mouse-deer, from Malaysia as new species; the form from each islet being regarded as a distinct species. Those named by Mr. Miller from 1900 to 1902 have already been relegated to the rank of sub-species by Mr. J. L. Bonhote in a paper published in the March issue of the *Annals of Natural History*, and there is no doubt that this is the right way of dealing with such local variations, as they can then be disregarded by all but the specialist.

Notices of Books.

"RADIANT ENERGY AND ITS ANALYSIS." By Edgar L. Larkin, Director Lowe Observatory, Echo Mountain, California. (Baumgardt Publishing Company, Los Angeles, California. 1903.)—This work is different from any other text-book on astrophysics which we have seen. We cannot say it is more profound; we cannot say it is more lucid; but it is different. It is, perhaps, because of our imperfect acquaintance with the American language, but sometimes we could not do more than make a shrewd guess at the meaning of some of the paragraphs. For instance, on p. 17, we read: "These two, matter and energy, or possibly one, is the sum total of all that has been found during three centuries of incessant research in all that portion of the universe visible in a forty-inch telescope armed with the most powerful spectroscope ever made." We judged that the first clause meant that perhaps matter and energy were alternative forms of the same thing, but on page 41 we read: "Thus the undulatory theory of light was proven, for matter added to matter cannot destroy both—light is therefore not matter." We had always understood that light is a form of energy. And again on p. 289, "What mighty import hovers round the word evolution. For giant modes of energy wrought and struggled in war. Matter was shaken, oscillated, kneaded, boiled and trembled in the throes of chaos. Phantom forms of nebulæ were clutched in awful churning, in seething whirlpools, and throbbed with energy. Absolute zero and darkness reigned, useless indeed; cold light can be in the most frigid space." Evolution, indeed, he has found to be a blessed word, though we cannot hazard a surmise as to what sort of fearful wild fowl he considers it to be. In his summary on p. 293, he says, "That evolution set its mighty clutch on all existing matter when it was in an excessively rare ultra-gaseous or corpuscular state, filling all space now occupied by seas," and then in a page of emphatic though somewhat obscure description he traces the history of the Cosmos from that time until, "through contraction, heat developed, and light on small worlds after nearly all the heat had vanished, water came, and coarse life, then more refined, and lastly mind, along towards the close of evolution. It contemplates the stupendous scene for a few seconds and disappears." It may be from faulty proof-reading, or from the peculiarity of the language, but in very many instances the verbs and nouns do not agree, and we think that the meaning might be somewhat clearer if they did. But it is the index that we find of most unexpected interest. In casually glancing through the Ms, we found wedged between "Miss Maury, Measurement of Graphs," and "Meridian Photometer," the reference "Men, Pale and Faint." On turning to p. 285, which was indicated, we read, "The new sun in Perseus last year was seen to resolve into a chaotic nebula. Mystery

deepens, while men pale and faint in presence of these mighty problems." After this it was a distinct disappointment to find that a statement on p. 231, "The planetary heavens would burn as heated brass, and the heats of Pelée and Soufrière would pale and faint," was not similarly indexed. The book is distinctly original, very amusing, and though we would not recommend it as a text-book to the young and innocent aspirant to scientific honour, we note with the most pleasurable anticipation that the author says in the "Introductory" that "enough material is now on hand to fill another volume like this."

"GEOLOGICAL RAMBLES IN EAST YORKSHIRE." By Thos. Sheppard, F.G.S. Pp. xii. and 236. With about 50 illustrations and a coloured geological map. (London: A. Brown and Sons, Ltd.)—This handsomely printed book is dedicated to Messrs. P. F. Kendall and G. W. Lamplugh, and the frequent references to the work of these geologists shows under what a powerful spell the author has fallen in his rambles on the Yorkshire coast. On p. 31 he writes, with a welcome and just enthusiasm, "to such an extent is Mr. Lamplugh connected with the geology of this district, that to speak of the latter without the former would be equal to playing 'Hamlet' without the Prince of Denmark." Throughout the descriptions, the reader feels that he forms one of a friendly party, to which the untiring zeal of Mr. Kendall, or the penetrating geniality of Mr. Lamplugh, furnishes a continuous inspiration. Mr. Sheppard is content to act as the recorder, and there is no reason to doubt his accuracy in so doing.

The author makes, perhaps, too much claim on the knowledge of the reader at the outset. We should have liked to start with a sweeping survey, a comprehensive view, from the great plain of York, fit for the civilisation of imperial Rome, to the bare Wolds eastward, and thence to the strange and shifting coastland, which seems to connect Yorkshire with the flats of Holland and the Baltic. The course of the Derwent, again, excites the imagination when set down upon the map. We have a right to look for some geographical grasp from those who offer themselves as geological guides in so interesting a country.

The remarks on pp. 110—111 as to the value of fossils in recording the history of a district are clearly addressed to the untrained visitor. But we want more such explanations, and to find them in the opening chapters, if the book is aimed at the majority. What will the ordinary reader make of the zoning of the Speeton clay (p. 67), or the terms Cretaceous, Oolitic, and Liassic on p. 38, or the phrase "oolitic sandstone" on p. 136, where "oolitic" is probably used in its unfortunate stratigraphical sense, as on p. 109, and in the table on p. 101, and not lithologically, as one would suppose from the statements on p. 92. Surely it is time that the international term Jurassic should displace our local and misleading terminology. We cannot do away with "Carboniferous Limestone," or "Cretaceous Chert"; but a way has been opened by which we can avoid "Middle Oolite," "Lower Oolite," and so forth. On p. 92 the author uses the word Jurassic, but, by a slip, as equivalent to the "Oolitic system."

A few phrases in an otherwise clear and readable book require emendation. On p. 47 we learn that "the discovery referred to consisted of a streak of greenish coloured sand, about 24 feet long, and rarely exceeded 4 inches in thickness." On p. 133, the whorls of an ammonite are said to be "divided into a number of septa or cell walls," instead of into a number of chambers. On p. 55, it is implied that great earth-movements have not taken place in Britain since Palæozoic times. A study of the Isle of Wight or the Dorset coast would surely have corrected this impression. Yet a certain ingenuousness on the part of the author, and his delight in the features of his chosen locality, disarm the professional geologist, who wants to look at all things from the point of view of effectiveness in a lecture-room. Let us thank Mr. Sheppard for a distinctly helpful volume, and for such fine illustrations as those of Bempton Cliffs (p. 41), the Boulder-clay of Filey (p. 74), and the Gristhorpe coast with its overhanging cornice (p. 89); in addition to which many others should be mentioned.

"AN INTRODUCTION TO BOTANY." By W. C. Stevens. Pp. viii. and 436 and 127. Ff. 350. (Heath & Co.) Price 6s.—In this excellent text-book the author emphasises the importance of practical work. The chapters open with observations for guidance in this, followed by a discussion on the leading points. Preliminary remarks on laboratory work precede a series of chapters dealing with the various parts of plants, beginning with seeds and seedlings and passing on to flowers. The remaining chapters will afford the beginner a general view of the subject. The book is written by an American Professor, primarily for American students, hence the "Flora" at the end is naturally a selection of American plants.

"ASTRONOMY FOR EVERYBODY." A Popular Exposition of the Wonders of the Heavens. By Prof. Simon Newcomb, LL.D. (London: Isbister & Co.) 1903. Pp. xv. and 341. 7s. 6d.—Despite the great promise of the introductory chapter, we must confess to a feeling of disappointment with this book as a whole. While giving an orderly elementary account of astronomical phenomena and the uses of the principal astronomical instruments, it seems to us to deal inadequately with the kind of observations which everyone may make, and also with the revelations of the telescope. It is besides difficult to understand why Prof. Newcomb has not availed himself to a greater extent of the wealth of material now available for the purpose of illustration. Many of the diagrams are unattractive, and the reproductions of photographs, which are only four in number, are not by any means excellent. Nebulæ, of which so many magnificent photographs have been taken in recent years, are not pictorially represented in any shape or form, and the forms of comets are only exhibited by three very inferior drawings of Donati's comet of 1858. It may also be pointed out that the path of the rays in a Newtonian reflector is incorrectly shown in Fig. 13. As might be expected, the text is thoroughly trustworthy and interesting so far as it goes, and the reader who masters it will have but little to unlearn if he should happily be induced to pursue his studies. It should be noted, however, that the doubt expressed on p. 148 as to the presence of dark lines in the spectrum of the corona is no longer justified, and also that no considerable proportion of the lines in the spectra of the Orion stars are now to be attributed to unknown substances (p. 295).

"ON THE DISTRIBUTION OF RAIN OVER THE BRITISH ISLES DURING THE YEAR 1902." Compiled by H. Sowerby Wallace and Hugh Robert Mill, D.SC., LL.D. (Stanford.) 10s.—No country in the world possesses so excellent a corps of rainfall observers as the British Isles. There are no less than 3500 of them, and their observations are here given for the year 1902. "British Rainfall" is as familiar as household words to meteorologists, but it is a publication that engineers, agriculturalists, sanitary authorities, and others will also find of service and interest. If such refer to this book they will find no difficulty in learning whether any statistics are available for any given locality, because the excellent way in which the stations are grouped into counties makes the search easy. With such a multitude of stations it is, of course, not feasible to give detailed observations for them all, so that in the majority of cases only the total fall for the year is given, together with the number of days during the year on which rain fell. But it is not enough merely to know the amount of rain that fell, since for many purposes it is desirable to learn what happens to the rain when it reaches the ground. To this end, therefore, this book includes for a few stations observations concerning evaporation and percolation, although it could be wished that still more figures concerning these important factors were available. The tables showing the number of droughts experienced during the year will prove of great utility, fifty representative stations being chosen for investigation. Another important point concerning water-courses and their capacity for carrying off storm water is elucidated by the note on heavy rains experienced during short periods, and also by the table which records the number of days that had unusually heavy rains. Mr. Wallace would appear to think that the interest in the record of a year's rainfall must to some extent wane in the six months necessary for its publication; but he and Dr. Mill are to be congratulated on the quickness with which they have published this volume, a quickness, it may be said, that could be imitated by other meteorologists with advantage.

"THE STRUCTURE OF THE NUCLEUS." A continuation of "Experiments with Ionized Air," by Carl Barus. (Smithsonian

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Contributions to Knowledge. 1903.)—This valuable memoir is a continuation of the "U.S. Weather Bureau, Bulletin 12" (1893), and of the "Smithsonian Contributions to Knowledge," Vol. XXIX. (1901), by the same author, and but for a little prefatory "advertisement" by Prof. Langley it would be very difficult for the reader to understand Prof. Barus' present researches without a careful study of the previous works. Even as it is, it is much to be regretted that Prof. Barus has not given a concise summary of the objects, methods and results of the two previous papers; and especially has not clearly defined both "nucleus" and "corona," and given a description or representation of some of the forms of the latter. Apparently nuclei are extremely small particles tending to precipitate water from moist air, when this is suddenly cooled, and in the present researches they were usually supplied by introducing into the receiver air which had passed over phosphorus, or burning sulphur, or glowing charcoal. They could be obtained, however, without putting anything material into the receiver, by passing the X-rays or other form of radiation through it. Here the production of nuclei in case of weak radiation is very gradual, and it takes time to produce them, but when once produced they show a degree of persistence identical with that of nuclei of any other origin. Since there is no qualitative difference referable to their origin, the stuff out of which their nuclei are made must be in the gaseous contents of the receiver (air or vapour). The chief aim of the memoir is to throw light on the phenomena connected with the presence of nuclei in air by aid of the "coronas" or colour rings seen in such air where its moisture is condensed and deposited on the nuclei, and a distant source of light is looked at through the turbid medium. The author accepts the theory that nuclei which vanish are absorbed on contact with the walls of the vessel, and that no other loss of nuclei occurs. Nuclei are sparsely distributed (10^3 to 10^6 per cub. cm.) in comparison with molecules. In using an emanation of phosphorus as an ionizer, the author found incidentally that, under certain conditions, the emanation produced permanent conduction in the condenser. This he identified with the occurrence of traces of moisture, but the behaviour so closely resembled the effects of radio-activity, that he concluded that the latter quality could only be predicated with extreme caution.

BOOKS RECEIVED.

Treatise on Zoology. Edited by E. Ray Lankester, M.A., LL.D., F.R.S. Part I.—*Introduction and Protozoa.* By J. B. Farmer, D.SC., F.R.S.; J. J. Lister, M.A., F.R.S.; E. A. Minchin, M.A.; and S. J. Hickson, F.R.S. (A. & C. Black.) Illustrated. 15s. net.

Memoirs of the British Astronomical Association. Fifth Report of the Section for the Observation of Mars. 3s.

The Crowd. By Gustave le Bon. (Fisher Unwin.) 6s.

Buddhist India. By T. W. Rhys Davids, LL.D., PH.D. (Fisher Unwin.) 5s.

Fundamental Problems. By Dr. Paul Carus. (Kegan Paul.) 7s. 6d.

Position of the Old Red Sandstone in the Geological Succession. By A. G. M. Thomson, F.G.S. (Dundee: John Leng & Co.)

School Geometry. Part III. By H. S. Hall, M.A., and F. H. Stevens, M.A. (Macmillan.) 1s.

Smithsonian Institution. Report of the U.S. National Museum for the Year ending June 30th, 1900. (Washington: Government Printing Office)

Smithsonian Institution. List of Publications, 1846–1903.

Doubts about Darwinism. By a Semi-Darwinian. (Longmans.) 3s. 6d.

Elementary Chemistry of Photographic Chemicals. By C. Sordes Ellis, F.I.C., F.C.S. (Hazell, Watson & Viney.) 1s. net.

The Surd of Metaphysics. By Dr. Paul Carus. (Kegan Paul.) 5s. 6d. net.

Karma. By Dr. Paul Carus. (Kegan Paul.) 1s.

Practical Management of Pure Yeast. By Alfred Jörgensen. *(Brewing Trade Review.)* 5s. net.

Portraiture for Amateurs without a Studio. Parts I. and II. By Rev. F. C. Lambert, M.A. (Hazell, Watson & Viney.) 1s. net.

Economic Ideals. By James Dundas White, M.A., LL.D. (F. R. Henderson.) 2s. net.

Steel and Iron. By Arthur H. Hiorns. (Macmillan.) 10s. 6d.

Algebra. Part II. By E. M. Langley, M.A., and S. R. N. Bradley, M.A. (Murray.) 2s.

Physical Chemistry. By Dr. Ernst Cohen. (Geo. Bell & Sons.) 6s. net.

Traverse Tables. By Robert Shortrede, F.R.A.S. (Layton.)

Notes of My Life. By George Wyld, M.D. (Kegan Paul.) 3s. 6d. net.

Bulletin de la Société Astronomique Flammarion de Montpellier. July, 1903.

Prevalence of Gales on the Coasts of the British Islands during the 30 Years, 1871–1900. By Frederick J. Brodie, F.R.MET.SOC. (Royal Meteorological Society.)

Catalogue of 1520 Bright Stars. (Cambridge Observatory, Mass.)

Provisional Catalogue of Variable Stars. (Cambridge Observatory, Mass.)

Marl-Slate and Yellow Sands of Northumberland and Durham. By Prof. G. A. Lebour, M.A., M.SC., F.G.S. (Andrew Reid & Co.)

Institute of Mining Engineers. Thirteenth Annual Report of the Council. (Andrew Reid & Co.)

Phthisis Viewed in Relation to Dartmoor, to Devonshire in General, and to Constitution. By William H. Pearse, M.D. (Baillière, Tindall & Cox.)

Carbon Photography Made Easy. By Thomas Illingworth. (Iliffe.) 1s. net.

The Boiling Lake of Dominica. By F. Sterns-Fadelle. (Dominica: *The Dominican* Office.) 1s.

THE VATICAN OBSERVATORY.

By W. ALFRED PARR.

WHEN towards the middle of the ninth century Pope Leo. IV. sought to stem the further ravages of the Saracen hordes by strengthening the defences of Rome and enclosing the Vatican hill with massive turreted walls, he could little imagine that these same walls, designed so well to bear the engines of war that were to dominate the country round, would, more than a thousand years later, be required by a successor and namesake to harbour a weapon of science of a potency little dreamt of in those days—a weapon whose range of power should penetrate to the confines of the unknown itself. For, after the conclusion of the International Photographic Conference on the charting of the heavens, held in Paris in 1889, it was on one of the strongest of the towers forming part of the ancient Leonine wall that the late Pontiff, Leo XIII., decided to erect the newly-ordered astrographic telescope which was to enable the Vatican Observatory, until that time somewhat meagrely equipped, to worthily enter the lists with the seventeen other observatories to whom the work of the chart had been allotted.

The history of the Vatican Observatory is no less interesting than varied. Closely associated in its earliest years with one of the most memorable achievements in the annals of mathematical science—the reform of the calendar in 1582, under Gregory XIII.—it was shortly afterwards suffered to lapse into complete neglect for nearly a century and a half. Gregory, however, may be said to have founded the observatory when he erected that lofty portion of the Vatican Palace known as the "*Torre dei Venti*," not, as some rather uncharitably maintained, in order merely to enjoy the extended view obtainable from its summit, but in order to institute the study of celestial phenomena in general. That the latter purpose was the true one seems amply evidenced by the tower being referred to in the inscriptions as the "*turris astrorum speculatrix*," and by the fact that it contained the meridian line, constructed to demonstrate to Gregory that, in his time,

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the sun no longer entered the sign Aries on the orthodox 21st of March; a circumstance which, as seriously affecting the date of Easter, gave Gregory the opportunity of conferring a lasting *éclat* on his pontificate by undertaking the long-desired reform of the calendar. This reform, projected by the Neapolitan physician and astronomer, Lilio, and afterwards more fully demonstrated by the Jesuit, Clavius, was established by papal brief in 1582, but so strong was the feeling against the measure in all countries not adhering to the Church of Rome that it was not adopted by Germany until after the energetic representations of Leibnitz and others in 1700, nor by England until more than half a century later, when its introduction met with the greatest opposition, while

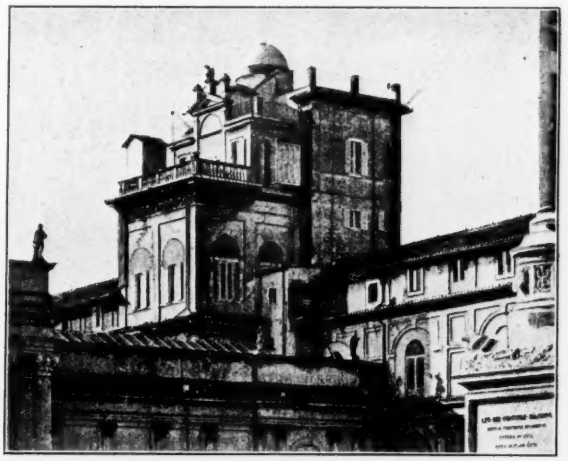

FIG. 1.—The Gregorian Tower of the Vatican Observatory.

Russia disregards it even to-day. The significant appearance on the official seal of the Vatican Observatory of the Ram's Head, symbolical of the sun's position at the vernal equinox, still serves to commemorate the connection between the Gregorian Tower and the Gregorian Calendar. Though, from its height of 73m. above sea-level, well enough adapted for the astronomical work of those times, the "Tower of the winds" did not long enjoy its reputation as an observatory, and it was only towards the end of the eighteenth century that it began, in a measure, to regain the importance of its earlier days. Meteorology, however, rather than astronomy, now formed the chief study, for it had been found that, as the vast dome of St. Peter's somewhat impeded the view towards the south, the site was less favourably placed for astronomical work than that occupied by the observatory of the Collegio Romano, erected in 1787, and rendered famous through the labours of De Vico and his illustrious successor Secchi. Nevertheless, for some thirty years after 1789 the Vatican Observatory continued to display considerable activity in observational work under Gilii, but after his death in 1821 it again fell into disuse, the instruments becoming gradually dispersed and the place itself deserted, until, after the political events of 1870, when the Italian troops took formal possession of the Eternal City, and Pius IX. entered upon his self-imposed imprisonment in the Vatican, the locale of the observatory, owing to the exigencies of space, was finally transformed into dwelling apartments.

But in spite of this fall, the strangely chequered fortunes of the venerable institution were not to end here, for the observatory was soon to enter upon the last and most active period of its existence—that which recognises in it the well-known and well-equipped *Specola Vaticana* of to-day. The immediate cause of this resuscitation was the scientific exhibition held at Rome in 1888 to commemorate the Jubilee of Leo XIII. At its close the late Father Denza, whose name had been for many years before the scientific world, suggested to the Pope that the collection of instruments forming part of the exhibition should be made use of to reconstitute the Vatican Observatory. This project not only met the immediate approval of Leo XIII., himself a mathematical prizeman of earlier years, but was so enthusiastically carried through that by the summer of 1889 Denza had nearly all his instruments installed, and was able to attend the International Photographic Congress at Paris as representative of the Vatican Observatory, and to claim for the newly reconstructed institution a place among the eighteen great observatories taking part in Admiral Mouchez's grandiose scheme of charting the heavens. Under the formal directorship of Denza the observatory was now equipped with all the most modern meteorological, magnetic, and seismological instruments, many of them being the first to be introduced into an Italian observatory, while its purely astronomical department was enriched by the addition of the astrographic telescope constructed in Paris by the Brothers Henry, and mounted by Gautier, of the Paris Observatory. This instrument, which, like its Paris congener, is mounted on the so-called English system, is carried on piers of white Carrara marble, and consists of the usual pair of telescopes contained in a rectangular case of metal, the photographic telescope having the regulation aperture of 33 cm. to a focal length of 3·43 m., and the visual one an aperture of 20 cm. to 3·60 m. focal

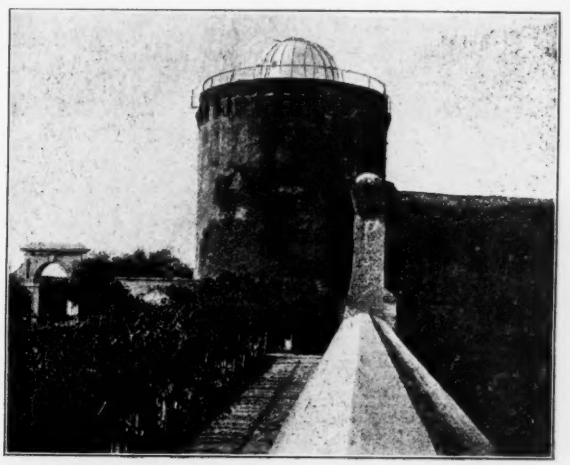

FIG. 2.—The Leonine Tower.

distance. It was placed in position in May, 1891, on the strongest of the towers belonging to the ancient Leonine wall mentioned above.

Curious as was the anachronism of fitting one of the most specialized products of the nineteenth century to a structure dating from the ninth, the old Leonine tower nevertheless proved itself admirably adapted for the novel purpose to which it was put; for situated as it is on the summit of the Vatican hill some 400 m. distant from the Gregorian tower, with which it is in telephonic communication, and, with its colossal walls of over 4 m. thickness, almost a monolith in strength, it unites in the happiest manner the elements of isolation and solidity so essential

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to the delicate nature of the work carried on beneath its modern dome.

Though primarily designed to co-operate with the great observatories in the work of the International astrographic chart and catalogue, the photographic department of the Vatican Observatory has by no means limited its activities to mere routine work, but has secured several good solar and lunar photographs in addition to its fine studies of nebulæ and star clusters, while a speciality has been made of cloud photography, the Vatican being well represented in this department at the Royal Meteorological Society's Exhibition, held in London in 1890, for the application of photography to meteorology.*

Under Denza, who worked assiduously at his post as director until his death in December, 1894, the Vatican Observatory rose to renewed life and activity, and, conjointly with its sister establishment in Sicily, Catania, entered with enthusiasm upon its share of that great international undertaking which was to bequeath to future times a photographic record of the entire heavens at the close of the nineteenth century. It was, however, reserved for Denza's successor to the directorship, Father Rodriguez, to whose kindness and courtesy I am indebted for many of the above details, as well as for the accompanying photographs, to see this monumental work (which requires some eleven thousand plates in order to cover the whole sky) brought, after several minor interruptions, to its present more or less completed condition.

MICROSCOPY

Conducted by M. I. CROSS.

THE COLLECTION, EXAMINATION, AND PRESERVATION OF MITES FOUND IN FRESH WATER (*Hydrachnidæ*).

By CHAS. D. SOAR, F.R.M.S.

ANYONE with a love for natural history wishing for a hobby for his spare time, would find the study of fresh-water mites (*Hydrachnidæ*) an extremely interesting one. For variety and beauty in colour, and for differences in form and structure, they are not to be surpassed by any other organisms found in fresh water. Wherever there is a pond, ditch, or stream, the collector is nearly sure of being rewarded for his search by finding one or more species of these interesting creatures. They are easily caught, and can be seen with the naked eye; they are, however, very seldom recognised without the aid of the microscope. They can be kept alive for a considerable period at home, and are easily preserved when killed.

At present the life-history of these little creatures is so imperfectly known that there is wide scope for an observant naturalist. Although the life-histories of some species have been fairly investigated, the number of such is very limited compared with the species known, and the variety of species which have been recorded in Great Britain are behind the recorded collections of Germany and elsewhere.

These creatures are caught in three distinct stages—the larval, the nymph, and the imago. In the larval stage they are very small, and only have six legs. When they first emerge from the egg they are free-swimming, but they soon become attached as parasites to some other form of Pond-life. They will often be found hanging like small red pear-shaped appendages on a great number of aquatic insects. The six legs they started life with disappear after they have become firmly attached by their mouth organs to their host, and they spend the remainder of this period of their existence without any.

This stage is succeeded by the nymph; the little creatures are then much larger and have eight legs. During this term of their existence they are free-swimming, and can be caught in the net in numbers, but it is impossible to distinguish the sexes.

In the last stage,—the adult or imago, all the structure and form are present, but many may be taken that are not fully developed. In the majority of species, the male can be distinguished from the female and the specific differences recognised; but there are some in which the sexes are so much alike that it is almost impossible to tell one from the other. In others, again, the sexes are so different—as, for instance, in the Arrhenuri—that one would be disinclined to think they could be of the same species.

The three figures are intended to convey to the beginner the three stages mentioned. Fig. 1 is the larva of *Piona nodatus* (Mull.). Fig. 2, the nymph of *Diplodontus despiciens* (Mull.), showing the ventral surface and the epimeral plates to which the eight legs are attached. Fig. 3 is the adult *Diplodontus despiciens* (Mull.), ventral surface of female.

There is another point in the adult stage to which it will be well to draw attention. When the mite has first made its

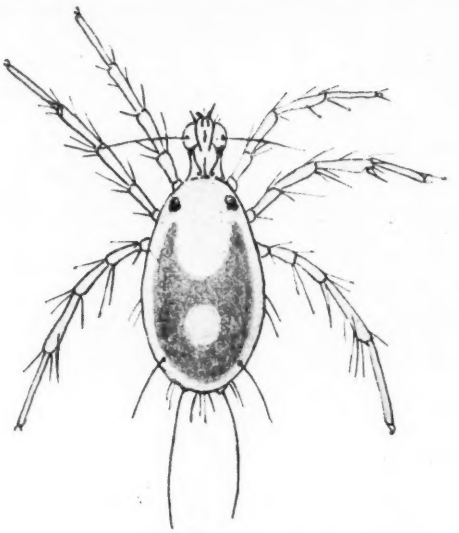


FIG. 1.

appearance from the inert period it spends between the nymph and adult stage, the hard and chitinous parts appear to be nearly fully developed, but the soft parts are not so. The body often appears very small, while the palpi, legs, and epimera, etc., are very large in proportion; it is also very poor in colour. It would be well to ascertain that the mites are quite developed before making drawings and taking measurements. In my ignorance, when I first began the study of water-mites, I had to discard a number of drawings I had made of different specimens because they afterwards proved to be only different stages of growth of the same species of mite.

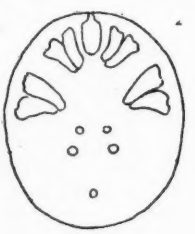


FIG. 2.

For collecting mites there is no better apparatus than the usual collecting stick used by pond hunters, having a metal ring attachable at its end which carries a cone-shaped net made of silk or muslin, with a glass tube at the bottom. The advantage of the tube is that the contents can be examined with an

* Reproductions of some of the Observatory's cloud photographs appeared in KNOWLEDGE for May, 1899.

ordinary pocket lens at any moment to ascertain if anything has been secured worth preserving.

It is advisable to carry as many bottles as the number of ponds that are likely to be visited; careful record should be kept of the exact locality where each mite is found, with the date of capture, and this cannot be done if all the specimens are carried home in one bottle.

The most convenient way of carrying collecting bottles is by sewing two strips of thick cloth together with loops of the required size in the same manner as a cartridge bandolier. Such

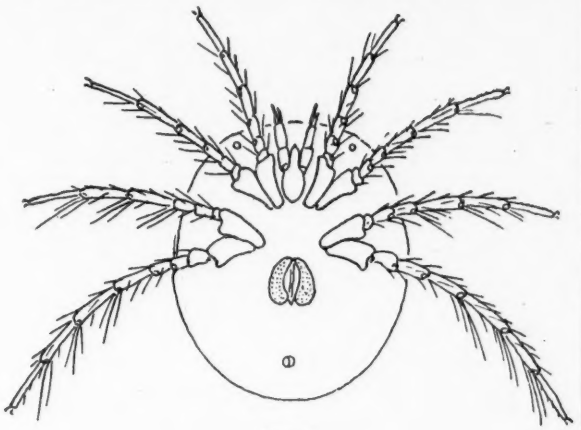


FIG. 3.

a device can be rolled and stood at the bottom of a bag, and obviates the chance of the bottles breaking by contact.

During the summer months it will generally be found that the most successful captures are made near the edges and in shallow parts of ponds; in the winter time the mites get into deeper water. Some mites are to be found only on the mud at the bottom of ponds, others on the leaves and stems of water-plants. In collecting, therefore, it is necessary to let the edge of the net just skim over the surface of the mud and sand, and up and down the stalks and stems of likely plants.

The under-surfaces of leaves should also be scraped with the edge of the net. Anacharis is a very favourite plant of water-mites, and wherever this is found it is almost certain that mites will be secured.

In addition to the free-swimming mites, there are a large number of parasitic forms, and it is as well to examine all forms of insect-life before discarding material. Fresh-water mussels, in particular, also the large water-snails and water-beetles, are specially to be recommended for examination, and, once more, let me emphasize that if anything is found, notes should be made of dates, places, and general details of the captures.

(To be continued.)

FOCUSSING IN PHOTO-MICROGRAPHY.—There are several devices in regular use which enable the object that is to be photographed to be viewed and focussed without reference to the ground-glass screen; among these are "Beck's Observing Prism," and Mr. Andrew Pringle's device for taking instantaneous photographs, which is described in his "Practical Photo-Micrography." But it would often be an immense convenience to the worker if, after focussing the object through the microscope, he merely had to set his camera in position and make the exposure, without readjustment in the camera itself. For many classes of work this is almost a necessity, and a suggestion offered by a contributor to the *Journal of Applied Microscopy* is an excellent and practical one.

Although the difference is small between the point of visual focus when examined directly through the eyepiece and when seen upon the ground-glass screen, it can be exactly adjusted by the use of a spectacle lens. This spectacle lens has to suit the individual user, the particular objective, and camera length, but with a variety of these glasses any condition may be provided for.

The simplest way would be to fix standards by first of all focussing the object sharply upon the ground-glass screen, removing the camera, and then, looking through the microscope eyepiece in the ordinary way, interpose between it and the eye (but particularly without altering any of the focussing adjustments) several of these spectacle lenses. When the one has been found that shows the object sharply and at its best, it may be retained for the special purpose in future, *i.e.*, the next time the same objective and camera length is to be used, after the usual focussing adjustments are made with the microscope, this particular lens will be interposed and the focussing altered the slight amount necessary. The camera will then be placed in position, and there will be no occasion to refer to the ground-glass screen to verify the focussing.

This system is good so far as objects are concerned with which eyepieces are used, but aid is often more particularly required where "Planar" and long focus lenses are employed without eyepieces. It is usual to insert an eyepiece to place the best part of the object in the centre of the field, then remove the eyepiece and re-adjust upon the ground-glass screen; but the difference between the two points of focus is very great, and with considerable camera length difficulty is often experienced in reaching the microscope adjustments: a hint in this direction may therefore be of value.

When observing with the eyepiece, a plano-convex lens of a focus which will vary according to the tube length and other considerations should be inserted in the lower end of the draw-tube. The object is then focussed with this in position. For photographing, the draw-tube is entirely removed together with the viewing lens and eyepiece, and if the same method of procedure is followed in this instance as in the one previously described above, there will be no occasion to re-focus on the ground-glass screen; all that will be necessary will be to view the image sharply focussed on the ground-glass screen experimentally in the first place, then find the lens which, when placed at the lower end of the draw-tube and the object viewed through the eyepiece, will give the same image sharply focussed to the eye without altering the adjustments.

OBJECTIVES FOR POND-LIFE EXAMINATION.—A Supplementary Note by Mr. C. F. ROUSSELET.—A few words on the most suitable object glasses for pond-life work may be useful to the uninitiated. It goes without saying that only the very best objectives will give permanent satisfaction. As low powers, the 1½ in. and ⅔ in are the most useful glasses and quite sufficient for all work, the ⅔ in. being, in my opinion, the highest power which can usefully, and with real advantage, be used with the binocular microscope. Then, for the study of the minuter structure of the animals, a higher power, giving a magnification of at least 300 diameters, is required. A thoroughly good ¼ in. or ⅙ in. object glass will answer this purpose. Both these glasses, however, have a very short working distance, which is a source of considerable trouble when working on living and moving objects in the compressor. In practice I have found Zeiss' 12 mm. (or ½ in.) apochromatic objective far better suited for this purpose. It has a good working distance of about ⅛th of an inch, and yields a most perfect image with the various compensating eyepieces, ranging from 84 to 378 diameters. This will cover most of the work the amateur is likely to do; but occasionally, for exceedingly minute anatomical details, an object glass of greater numerical aperture will be required, for which I recommend a ⅛ in. or $\frac{1}{10}$ in. apochromatic water-immersion lens.

NOTES AND QUERIES.

G. Damant.—I quite understand your difficulty, but it is practically impossible to obtain the light from one "spot" if an incandescent filament is used. I am afraid you will have to sacrifice the ideal in this respect. An incandescent bulb could be quite simply mounted on a vertical standard to do what you require, and very good results could be secured.

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

BORRELLY'S COMET formed a fairly conspicuous object in July, passing successively through Cygnus, Draco, and Ursa Major, but it has now approached too near to the sun for observation. Even

at the time of full moon on July 9 it continued visible to the naked eye, and seemed decidedly brighter, on the whole, than Perrine's comet of September and October, 1902. On July 19, as viewed in a field-glass, the comet had a tail about 2 degrees long, directed southwards, but it was difficult to assign exact limits owing to the faintness of the outer portions. It is rarely that the apparent paths of comets are placed so favourably in the sky for observational purposes as were those of Perrine and Borrelly, for the great majority of these visitors in their flights to and from the sun are not far above the horizon, and more or less involved in twilight and obscuring vapours. The two bodies alluded to passed, however, near the zenith, and being visible to the unaided eye could be readily followed through extensive ranges of the firmament. But it is to be remarked that while Perrine's comet of 1902 attracted a large amount of attention, the present object, though equally deserving, received comparatively little notice. In the case of the former, however, special comments were made in the newspapers soon after its discovery, and the probabilities of its developing into a comet of the largest class were exaggerated. Needless to say, the public expected much and saw practically nothing. Thus the present visitor has failed to excite much enthusiasm, for a good many people, having looked in vain for certain previous comets as well as for November meteors, are inclined to regard promised celestial apparitions as rather mythical in view of several past disappointing experiences.

Borrelly's comet has been very fully investigated at the Lick Observatory (Bulletin 47). Besides the observations for position, the spectrum has been carefully studied, and several photographs, both of the comet and its spectrum, have been secured. The spectrum consisted of the characteristic cometary bands, due to carbon or some of its compounds, and it may be worth while to mention that the three bands in the visible spectrum were easily seen by Mr. Fowler and others with a small slit spectroscope attached to a 3-inch refractor. Photographs taken before July 14th show two tails, one long, straight, and narrow, and the other of about one-third the length, and greatly curved, the latter being the brighter. On the last two days of June the longer tail was split into two branches, but on the day following it was again sharp and single. On July 14th the straight tail, extending over 8½ degrees, alone appears, widening out slightly as it extends away from the head. Throughout the period of observation, the straight tail was directed almost exactly away from the sun, and the nucleus was always sharply defined.

PERIODICAL COMETS.—Though seven of these interesting objects are due to return to perihelion this year, not one of them has been detected at the time of writing. The following is the complete list of the expected reappearances:—

Comet.	Probable Date of Perihelion, 1903.	Period of Revolution.
Tempel-Swift ...	January ...	5·547 years.
Brooks (1886 IV.) ...	March 25 ...	5·595 ,,
Perrine (1896 VII.)	April 27 ...	6·441 ,,
Faye	June 3 ...	7·488 ,,
Giacobini (1896 V.)	June 22 ...	6·647 ,,
Spitaler (1891 II.) ...	August 1 ...	6·378 ,,
Brooks (1889 V.) ...	December 11 ...	7·097 ,,

The failure to re-observe these objects is doubtless to be attributed in several cases to their unfavourable positions, but the number of large telescopes more or less employed in cometary work would lead us to expect more successes in this field. It should be remembered, however, that these comets are not only small, but that they are subject to physical changes inducing great variation in their luminosity. Holmes's comet was perceptible to the naked eye in 1892, but at its next return was visibly reduced to the 15th magnitude, and could only be distinguished in two telescopes, viz., the Yerkes 40-inch and the Lick 36-inch refractor. It is probable that some of these periodical comets are undergoing a process of disintegration similar to that which affected Biela's comet, and that in time many of them will lose their distinctive characters as cometary bodies, and be resolved into distended meteoric streams, only visible from our planet under the form of shooting stars. The two short-period comets of D'Arrest and Pons-Winnecke are due in January, 1904, but the circumstances attending their return are not favourable, and they are both likely to escape observation.

JULY METEORS.—The weather during the latter part of July was very unsettled, with much rain and cloud, so that few meteoric observations could be obtained. The writer, at Bristol, watched on July 24 for 1¾ hours, and saw 20 meteors, while on July 26 a 2 hours' watch yielded 20 meteors. The oncoming of the great Perseid shower was distinctly evident on July 24, though only three of its meteors were seen. Two of these were pretty bright, and appeared within 2 minutes of each other at 11h. 27m. and 11h. 29m. It is often the case that a pair of meteors from one and the same system make their apparitions within a short interval of time, and the inference is that the two bodies formed portions of what was originally one mass. Large individual meteors are probably often broken up by disturbances affecting them during their revolutions, and may be resolved into a number of small meteors moving in nearly concentric orbits. The writer has occasionally recorded, within a few seconds of each other, three meteors from a radiant which has given no further manifestation of activity during a watch of several hours' duration. On July 26 two or three small Perseids were seen, but the shower had apparently gained no strength since July 24. The principal radiant seemed to be near β Pegasi at 348°+25°. No Aquarids were observed. The most remarkable meteor recorded on the two nights appeared on July 26 at 12h. 45m. It moved with extreme slowness from 6½°+27° to 16°+14° in about 3¾ seconds, and came almost to a standstill at the end of its path. It had a dull reddish nucleus, and was directed from a radiant a long way back on its line of flight at 233°+38° near ζ Coronæ. The same meteor was well observed by Prof. A. S. Herschel at Slough, who gives the path as 291°+31° to 310½°+22°, and by Mr. A. King at Leicester, who recorded it as 315°−13° to 323½°−19½°. Prof. Herschel describes the colour as yellow, then reddish-orange, and estimated the duration of flight as 3½ to 4 seconds. Mr. King says the tint was deep orange, and duration 2¼ seconds. The meteor passed over the northern district of Hampshire, and fell from a height of 51 to 39 miles, along a path of 21 miles, with a velocity of 6½ miles per second. Atmospheric resistance had probably much reduced its original speed, and could the luminous career of the meteor have been prolonged until much nearer the earth's surface, a further "slowing up" would have become obvious.

A bright meteor, belonging to the α Andromedids of July, was observed by Prof. Herschel at Slough, and by the writer at Bristol, on July 26, 12h. 35m. It was seen nearly in the zenith of Slough, and here it appeared as bright as Sirius. The radiant was at 1°+27°, and height 66 to 46 miles, from Harrow to High Wycombe. Length of path 29 miles, and velocity 53 miles per second.

LARGE METEORS.—On July 1, at about 10h. 25m., a meteor brighter than Venus was seen by Mr. T. H. Astbury, of Wallingford, Berks, passing from 318°+32½° to 328°+26°. It left a white streak, enduring several seconds.

On July 30th, 11h. 40m., a magnificent meteor, "the size of a man's fist," was observed near Bishop's Stortford, high in the S.S.W., and passing towards S. It left a long train, and illuminated the landscape vividly. At Seaton, East Devon, the same meteor was seen in the N.E., and gave a brilliant flash. It travelled in a S.E. direction, and left a long trail of fire. It was also observed at Yarnscombe by several people, who were startled at the sudden outburst of light, and at first mistook it for lightning.

THE FACE OF THE SKY FOR SEPTEMBER.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 5.12 and sets at 6.48; on the 30th he rises at 5.58 and sets at 5.42.

The equation of time is negligible on the 2nd; this date, therefore, is suitable for the ready adjustment of sun-dials, etc.

The Zodiacal Light is prominent in the east, just before sunrise.

Autumn commences on the 24th, when the sun enters the sign of Libra at 6 A.M.

There is a total eclipse of the sun on the 21st, but only visible from the Antarctic area (*see* KNOWLEDGE, p. 121, vol. XXIV., 1901).

Sunspots and faculæ have been prevalent of late; at the time of writing there are three groups of spots on the solar disc.

THE MOON:—

	Phases.	H. M.
Sept. 7	○ Full Moon	0 20 A.M.
,, 14	☾ Last Quarter	1 14 P.M.
,, 21	● New Moon	4 31 A.M.
,, 28	☽ First Quarter	1 9 P.M.

The moon is in apogee on the 3rd and 30th, and in perigee on the 19th.

Occultations:—

			H.	M.	
3 Sept.	B.A.C. 7063	(Mag. 6·2) at	7	4	P.M.
11 „	D.M. +12° 436	(Mag. 5·9) at	11	53	P.M.
13 „	B.A.C. 1526	(Mag. 5·8) at	11	56	P.M.

THE PLANETS.—Mercury is an evening star in Virgo. On the 7th he is at greatest easterly elongation of 27° E., on which date he sets about 7 P.M. He is, however, not well placed for observing, but on the day of greatest elongation he has practically the same R.A. as γ Virginis, and is 6° to the south; this may be of some assistance in locating him.

Venus is unobservable, being in inferior conjunction with the sun on the 17th.

Mars is still visible in the south-west for a short time after sunset, but on account of his small altitude and his feeble luminosity, due to his increased distance from the earth, he is unsuitable for observation.

Jupiter is now becoming a brilliant object in the evening sky looking towards the S.E. He is in opposition to the sun on the 12th, when he attains his greatest apparent diameter, being then nearest the earth; on this date the polar and equatorial diameters are respectively 47″·1 and 50″·4.

The most interesting satellite phenomena visible before midnight are as follow:—

Date.	Satellite.	Phenomenon.	Time. P.M.	Date.	Satellite.	Phenomenon.	Time. P.M.
Sept			h. m.	Sept.			h. m.
1	I.	Tr. I.	8 16	21	III.	Sh. I.	8 10
„	I.	Sh. E.	10 17	„	III.	Tr. E.	10 22
„	II.	Sh. I.	10 23	„	III.	Sh. E.	11 26
„	I.	Tr. E.	10 33	23	I.	Oc. D.	10 43
„	II.	Tr. I.	10 59	24	I.	Tr. I.	7 52
3	II.	Oc. R.	8 0	„	I.	Sh. I.	8 11
„	III.	Ec. D.	10 13	„	I.	Tr. E.	10 9
8	I.	Sh. I.	9 53	„	I.	Sh. E.	10 29
„	I.	Tr. I.	9 59	„	II.	Oc. D.	11 59
9	I.	Oc. R.	9 32	25	I.	Ec. R.	7 45
10	II.	Oc. R.	10 13	26	II.	Sh. I.	7 37
15	I.	Tr. I.	11 42	„	II.	Tr. E.	9 34
„	I.	Sh. I.	11 48	„	II.	Sh. E.	10 21
16	I.	Oc. D.	8 59	27	IV.	Tr. I.	7 55
„	I.	Ec. R.	11 22	„	IV.	Tr. E.	11 2
17	I.	Tr. E.	8 25	„	IV.	Sh. I.	11 34
„	I.	Sh. E.	8 34	28	III.	Tr. I.	10 30
„	II.	Oc. D.	9 46				

Ec. = Eclipse. Tr. = Transit. Oc. = Occultation. Sh. = Shadow.
E. = Egress. I. = Ingress. D. = Disappears. R. = Reappears.

Saturn is rather low down in the sky, but otherwise is very favourably situated for easy observation in the evening; he is on the meridian at 9.45 P.M. on the 1st, and at 7.45 P.M. on the 30th, having an altitude of about 20°. The apparent polar diameter of the ball is 16″·6, whilst the outer major and minor axes of the ring have diameters of 41″·8 and 14″·4 respectively.

The ring is beautifully open, the ring plane being inclined at an angle of 20° to our line of vision, and we are looking on the northern surface.

Uranus is too low in the south-west to be easily observable.

Neptune is not in convenient position for observing until near midnight.

THE STARS.—At the beginning of the month, at 9 P.M., the following constellations are to be observed:—

ZENITH . Lyra, Cygnus.
SOUTH . Aquila, Delphinus, Aquarius, Capricornus, Sagittarius; Serpens, Ophiuchus, and Scorpio, to the S.W.
EAST . Andromeda, Pegasus, Pisces, and Aries; Pleiades on horizon.
WEST . Hercules, Corona, Boötes.
NORTH . Ursa Major, Ursa Minor; N.E., Cassiopeia and Perseus; Auriga (*Capella*) on horizon.

Minima of Algol occur on the 3rd at 0.37 A.M., 5th at 9.26 P.M., 25th at 11 9 P.M., 28th at 7.58 P.M.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of August Problems.

No. 1 (W. Geary).

1. Q to Ktsq., and mates next move.

No. 2 (A. Lillie).

[The author's key is 1. Q to R8, but there are several other solutions, *e.g.*, 1. Q to B4ch, 1. K to Kt7, 1. R to B7.]

SOLUTIONS received from "Alpha," 2, 6; W. Nash, 2, 6; G. A. Forde (Major), 2, 4; "Looker-on," 2, 6; W. H. S. M., 2, 6; G. W. Middleton, 2, 6; "Quidam," 2, 6; C. Johnston, 2, 6; H. F. Culmer, 2, 4; T. Dale, 2, 6; E. A. Servante, 2, 4; J. W. Dixon, 2, 6; A. C. Challenger (too late to count points).

"Quidam" has written to say that he sent in solutions of the May problems under his real name instead of his usual pseudonym. Hence the fact that he was not credited with points for them. The solutions were perfectly correct, and 6 points must accordingly be added to "Quidam's" score as published in the July number.

C. V. Howard.—Correct, but nearly a fortnight too late.

W. H. S. M.—Your postcard of June 27th postmark for some reason took three weeks to reach me, arriving just in time for a special correction after proofs. Your letter of August 10th (insufficiently stamped, by the way) contains solutions of July problems.

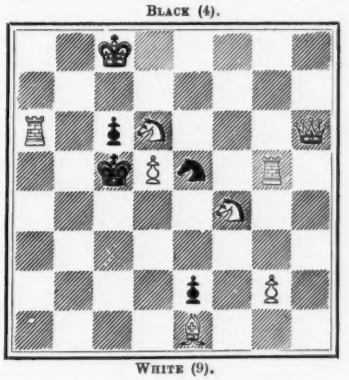
E. A. Servante.—The problems shall be examined. Could you not use more conventional diagrams?

PROBLEMS.

No. 1.

By H. N. Fellows (Wolverhampton).

BLACK (4).



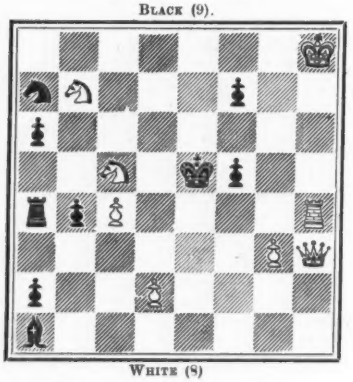
WHITE (9).

White mates in two moves.

No. 2.

By B. G. Laws.

BLACK (9).



WHITE (8)

White mates in three moves.

CHESS INTELLIGENCE.

The North *v.* South Correspondence Match has again been won by the South, but the margin of victory is much less decisive than on the last occasion. The final score was—South, 138; North, 114. On the Northern side the Lancashire and Cumberland players proved to be the most successful. The prizes offered for the best games were awarded to Mr. F. P. Carr, South (No. 8), and Mr. H. Doyle, North (No. 17).

Mr. Lasker, as might have been expected, has declined to accept the terms suggested by Mr. Marshall for a championship match. A match between Messrs. Lasker and Pillsbury seems a much more likely event, and would certainly arouse more interest.

Game played in the recent "King's Gambit" Tourney at Vienna.

"Muzio Gambit."

WHITE.	BLACK.
G. Maroczy.	M. Tchigorin.
1. P to K4	1. P to K4
2. P to KB4	2. P takes P
3. Kt to KB3	3. P to KKt4
4. B to B4	4. P to Kt5
5. Kt to B3 (*a*)	5. P takes Kt
6. Q takes P	6. P to Q3
7. P to Q4	7. B to K3
8. Kt to Q5 (*b*)	8. P to QB3
9. Castles	9. P takes Kt
10. P takes P	10. B to B4
11. B takes P	11. B to Kt3
12. B to Kt5ch	12. Kt to Q2
13. QR to Ksqch	13. B to K2
14. B takes P	14. K to Bsq (*c*)
15. R takes B!	15. Kt takes R
16. R to Ksq	16. K to Kt2 (*d*)
17. B takes KKt	17. Q to R4
18. Q to K2	18. Kt to Bsq (*e*)
19. B to B6ch	19. K to Ktsq
20. Q to K5	20. P to KR3
21. B takes R	21. P to B3
22. Q to K7	22. K takes B (*f*)
23. Q takes Pch	23. Resigns.

NOTES.

(*a*) The modern fashion, instead of 5. Castles, which used to be almost the invariable procedure. The text move has the advantage of forestalling the defence 7. . . . Q to B3, threatening Q to Q5ch if White had Castled.

(*b*) A very remarkable move, necessitating, presumably of set purpose, the sacrifice of another piece.

(*c*) 14. . . . Q to Kt3 certainly seems preferable. If then 15. Q to QR3, as suggested by the *Yorkshire Post*, Black could Castle on the Queen's side with apparent safety, before or after checking, without losing more than one of the pieces gained. The move made gives Herr Maroczy the opportunity for further brilliancy.

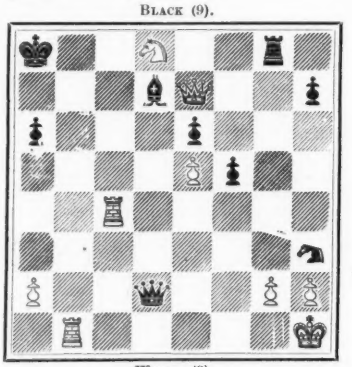
(*d*) Probably K to Ktsq would be better, in view of the colour of the diagonal occupied by the more prominent White Bishop.

(*e*) If 18. . . . QR to Qsq, 19. B × Kt, R × B; 20. B to B6ch, K to Bsq; 21. Q to K3 wins.

(*f*) If 22. . . . B to B2, 23. R to K3, Kt to Kt3; 24. R to KKt3, etc.

A correspondent sends the following very instructive ending of a game recently played:—

BLACK (9).



WHITE (9).

White mates in four moves.

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